TESTS OF A MECHANICAL RECTIFIER

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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TESTS OF A MECHANICAL RECTIFIER

A Thesis

PRESENTED BY

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and

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TABLE OF CONTENTS.

Introduction.....Page 1

Theory & Explanation of Rectifier..... 5

Instructions for Operating Rectifier..... 9

The Method of Procedure.....11

Results.....18

Tests of Motor.....21

Test of the Transformer.....26

Theory & Calculation of Thermocouple.....29

Oscillograph and Wave Forms.....32

Explanation of Diagrams, Tables & Curves....36

Conclusion.....48

Bibliography.....50

Data and Calculations.....51

Oscillograph Curves.....63

I.

INTRODUCTION.

INTRODUCTION.

At the present time the great number of new applications and uses of electricity, have enormously increased the necessity for an efficient form of a rectifying device.

This great need has developed on account of the various applications which require direct current, and mainly on account of the growing tendency of most of the large generating stations to produce alternating-current for power and lighting purposes. This tendency has been encouraged greatly since it was found much easier and more economical to transmit alternating current than to transmit currents of uni-direction.

The ease of transmission of alternating currents is due mainly to the higher potentials at which these currents may be transmitted. This is usually taken care of by the various methods of connecting in transformers. Since large voltages are possible, small currents can be used; hence a saving of copper, which is due to the use of smaller sizes of wires.

In the electrical field many instances may be noted where direct-current is absolutely necessary, so that the problems of rectification becomes a rather important one, and is invariably left to the consumer, who is naturally on the outlook for the most practical and efficient device.

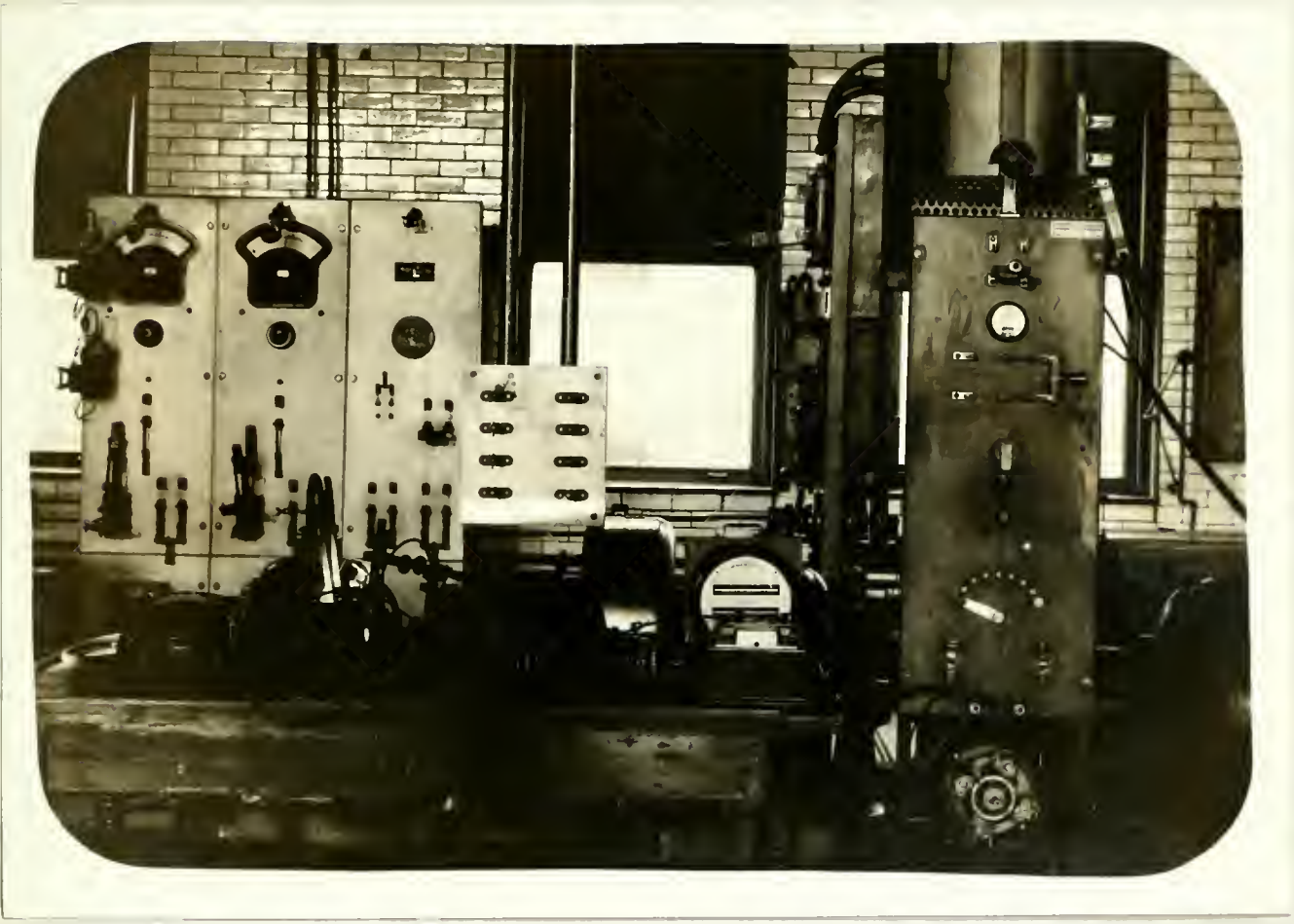
In looking over the field where rectifiers may be employed for converting alternating current into one of uni-direction, we find that direct current is used for power for ignition coils, for charging storage batteries for small direct current motors, series arc lighting, for the arcs of motion picture machines, and for a great number of other purposes.

In the past number of years as the motion picture business has advanced so rapidly, a great field has been established for an efficient type of a rectifying device, for rectifying alternating currents into direct current for the arcs of motion picture machines.

In looking over the localities of the motion picture theatres, it is found that most of them are furnished with alternating current. This cur-

rent must be rectified into direct current before it can be used for the arcs of the picture machines. Since every theatre that is furnished with alternating current must have some type of rectifier, it can easily be seen that the most efficient and practical rectifier will be favored by the theatre managers. The rectifier is in most cases located in the operating room, which is in most cases very small; and therefore a rectifier which occupies the least space would be the most logical machine to be used. As the commutator Rectifier occupies very little space, it can easily be seen that this type of rectifier would be the most practical one.

In the use of the Commutator Rectifier, we will endeavor to confine our work to the problems of rectifying alternating current to direct current, for the purpose of supplying current for the arcs of motion picture machines.



Photograph of Rectifier, with Instruments for Testing Same at the Left.

THEORY AND EXPLANATION

of

RECTIFIER

THEORY AND EXPLANATION OF RECTIFIER.

The mechanical rectifier consists of a synchronous motor, which starts up as a single-phase induction motor. This motor has a commutator rectifier for the purpose of rectifying alternating current into direct current. The motor is mounted on an iron stand. On the same stand is placed the switch board with all the necessary auxiliary apparatus. This motor is a split-phase single-phase induction motor on starting and a synchronous motor on running. The theory of a split-phase motor is as follows: the stator of the motor is provided with a two-phase winding, and these two-phases are connected in parallel to the single-phase supply mains with a resistance or a condenser in series with one of the phases. Under these conditions the currents in the two stator windings are out of phase with each other sufficiently to produce the desired starting torque, and when the machine reaches moderate speed, one of the stator windings is disconnected and the machine runs as a synchronous motor. The switchboard contains the following auxiliary apparatus: A transformer with

five different secondaries connected in such a way that the voltage could be stepped down from 110 to 60, 65, 70, 75 or 80 volts. An ammeter to indicate the current, a reversing or polarity switch to change the direction of the current in case the polarity is wrong, a low voltage circuit breaker which disconnects the circuit whenever the voltage becomes lower than about 70 volts. A resistance wire is also connected in series in order to keep a steady current through the arc.

The principle of commutator rectifier is as follows: The single-phase induction motor described drives a two-segment commutator on which are four brushes as shown in the accompanying diagram. The motor is started and brought up to the proper speed which is one revolution for two cycles of the current. The transformer switch is closed and the brushes shifted so that the insulation passes under the brushes at the zero point of the current curve. Once adjusted they will remain all right unless the commutator or brushes slip from their rigid position.

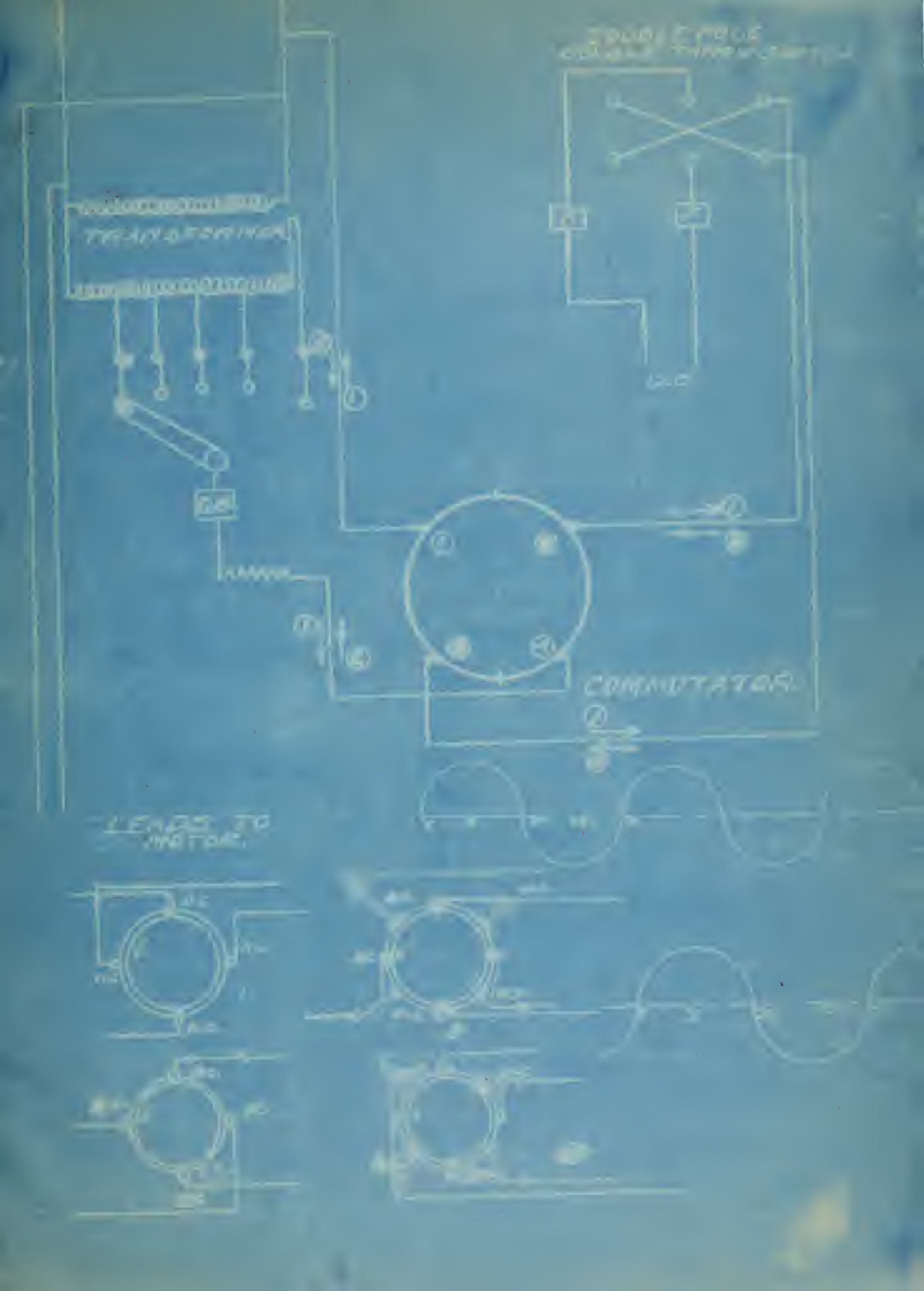
When the brushes are over the insulation at

the zero value of the alternating current wave there will be no sparking and the process of rectification will be the following:-

Let the insulation be between brushes 3 and 4 and assume the alternating current to flow as shown by arrow labeled (1). Let the direction of rotation be as shown by the arrow. The current flows in brush 4 from the transformer, through the commutator segment to brush 2 to the double pole switch to the D.C. load and back to brush 3 through the other commutator segment to brush 1 to other side of alternating current line.

When the insulation is under the brushes 2 and 3 or 1 and 4 the current wave will be zero. After the insulation passes the brushes and the insulation will be between 1 and 3 the current will flow into brush 1 through commutator to brush 2 through double pole switch as before through D.C. load to brush 3 and out brush 4 through the transformer to A.C. supply.

Figs. I to V in the accompanying diagram show all the different positions of the brushes, for a complete revolution and the corresponding values of the current are shown on the curve as marked.


COMMUTATOR.

INSTRUCTIONS

For

OPERATING THE

COMMUTATOR RECTIFIER.

Instructions for Operating Rectifier.

In Starting Rectifier,

First - See that all switches are open.

Second - Close service switch.

Third - Hold in circuit breaker and close polarity switch.

Fourth - Get desired polarity by polarity switch.

In Shutting Down, -

First - Throw off load by opening polarity switch.

Second - Open service switch.

THE METHOD

Of

PROCEDURE.

METHOD.

In preparing for the tests to be made upon the mechanical rectifier, the necessary instruments were first calibrated. These instruments were calibrated by direct comparison with standard instruments. The same instruments were used on both sides of the rectifier.

The alternating-current instruments were used on both sides for the following reasons:

(1) The alternating-current instruments indicate the effective value of the current, and all the current taken by the rectifier is converted into heat. Heat is proportional to the square of the current multiplied by the resistance, and the current in the equation, current squared multiplied by the resistance, is the effective value of the current. Hence the use of the alternating-current instruments.

Secondly, if direct-current instruments were used on the direct current side of the rectifier, it would be necessary to multiply the direct current readings of the ammeter by the ratio of the

effective to the average value in order to obtain the efficiency of the machine. In order to use the same instruments, and not have to connect and disconnect them after every reading of the alternating current and direct current side, a selector switch was used. The connections are shown on diagram I.

The instruments used in performing the tests were as follows:

1. The voltmeter was of the Hartman and Braun electrodynamometer type (0-130) volts.

2. The ammeter was a G. E. (0-30) (0-60) amperes No. 205833. The wattmeter was an S & H. Precision Wattmeter; maximum current 100 amperes.

The rectifier was tested with three different generators as the source of supply. The first was approximately of the sine wave form, the second was of actual sine wave form, while the third was of the peaked wave form.

The generator supplying the near-sine wave was built by the General Electric Company. three-phase, 110 volt, and driven by a 15 H.P. interpole 110 volt direct-current motor. The motor drove

the generator at a speed giving sixty cycles per second. The frequency was maintained constant by a rheostat in the generator field. The generator was separately excited from the same source which supplied the motor. The voltage of the generator was indicated by a (0-130) voltmeter of dynamometer type, and the frequency by a frequency meter. These two instruments were connected across the terminals of the generator.

The generator supplying the sine wave was built by Western Electric Company, 30 kw. three-phase, 2300 volt, stepped down by means of transformer to 220 volts or 110 volts. If the secondaries are connected in series 220 volts are obtained, but if connected in parallel 110 volts are obtained. This machine was driven by a 75 horsepower motor.

In the third test a generator giving a peaked wave was used. This machine was a single phase, 1100 volt, and was connected directly to a 35 horsepower motor. The speed of the motor was controlled by a field rheostat, while the generator

voltage was varied by means of its field rheostat. In this case the field was separately excited from the same source which supplied the motor. The power from the generator was transmitted to two Westinghouse transformers, each of 5 K.W. capacity, and of one to ten ratio of transformation. The high tension side of these transformers were connected in parallel, while the secondaries were connected in series. The instruments were connected as previously explained; the ammeter and wattmeter were connected across the terminals of the generator. The frequency meter was connected in parallel with the voltmeter. In two of the experiments resistance boxes and lamp racks were used as loads, while in the third experiment an arc lamp was used as the load. A test was also performed whereby the direct current side of the rectifier was short circuited for about five minutes, and readings were taken for power, current, and voltage.

In making the various tests, the direct current side of the rectifier was loaded up, and readings were taken for power, current and voltage for the direct current side as well as for the alter-

nating current side for loads varying from five to fifty amperes, at ten ampere intervals. The same process was repeated for the various voltage transformations. The above method was followed out in a similar manner, in performing the rectifier experiments, with the other generators. From the data obtained, in carrying out the experiments, the power factor and efficiencies were calculated, and curves were plotted to correspond to the data and calculations as shown in the tables III, IV, and V. and the corresponding curves are shown in the plates V to X inclusive.

The efficiency of the rectifier is the output divided by the input. Where the output is the direct-current readings and the input is taken as the alternating-current watts taken by the rectifier.

The power factor is the power in the alternating-current side, divided by the product of the amperes by the voltage on the same side of the rectifier. While performing these experiments, readings of the rise in temperature of the

outside surface of the yoke was taken with the thermometer, while the inside wiring was taken by means of the thermocouple.

In making a test with the arc lamp as the load, much trouble was encountered in trying to get precise readings of the instruments. This was due to the fact that as the carbons became separated, the current changed, and therefore the readings varied. In order to obtain a constant current through the arc lamp it was necessary to either insert resistance in series with the arc, or to keep the distances between the carbons constant.

RESULTS.

RESULTS.

The overall efficiency of the rectifier for the different ratios of transformation of voltages and corresponding loads, varied from about 45 per cent. with an average of about 60 per cent. This efficiency, however, is not the correct efficiency of the rectifier as it includes the power lost in the resistance. Although the power lost in the resistance is large, it cannot be dispensed with, as it is necessary for the operation of the arc lamp. If the efficiency of the rectifier were calculated independent of the resistance, much higher results would have been obtained. In noting this decided increase in efficiency, it can easily be seen that it is not fair to charge this loss of power to the rectifier, as the resistance is necessary for the arc lamp.

The power factor of the rectifier changed slightly with a variation of the ratio of transformation of voltages, and with a change of the loads. This was found to average about 95 per

cent. In the two short circuit tests, the power factor averaged about 90 per cent., and also when an induction motor was inserted in parallel with the generator, the power factor averaged 90 per cent. The purpose of this test was to discover what changes in power factor would be brought about by the addition of an inductive load being placed on the rectifier.

While performing the above experiments, the rise in temperature of motor on the outside surface of the yoke, as well as the internal temperature, was taken simultaneously. The results of these changes are shown on table XI. The curves indicating these changes are shown on plate XVIII. They are as follows: The rise in temperature on the outside surface was about 40 degrees to about 45 degrees Centigrade, while the rise in temperature of the interior of the motor was about 50 degrees Centigrade. These readings were taken at intervals of about every half hour, throughout the completion of the experiments, which took about five hours.

TESTS
of
MOTOR

TEST OF MOTOR

The motor was tested by the direct method of output and input. In order to test for the efficiency and power factor of the motor by the direct method, a three inch iron pulley was constructed, to fit a one-half inch shaft of the motor. A prony brake was next constructed, which consisted of a brass strip three quarters of an inch wide. Grooved blocks were screwed to the brass so as to fit the pulley. By means of a screw, the tension on the pulley could be requested.

Three different experiments were performed on the motor. Although they were all of the same nature, as far as the theory is concerned, different conditions were chosen for carrying out each one.

In performing the motor tests, the apparatus was all disconnected, and the motor was directly connected to the terminals of the prime mover. The prony brake was next attached to the motor, the brake arm was found to be eight inches in length. The scale used was of the platform type and could

be read correctly to one-hundredth of a pound. The load was increased at intervals of one fourth pounds, and readings of volts, current, watts and pounds were taken. Having obtained the data as stated above and knowing the length of the brake arm, the efficiency, power factor, and torque of the motor was calculated. The horsepower output of the motor was calculated by means of the equation,

$$H.P. = 2\pi LNP \div 33000$$

Where L is the length of the brak arm in feet, N the number of revolutions per minute, P the force or pull on scale, in pounds. When L is given in inches the equation becomes

$$H.P. = 2\pi LNP \div (33000 \times 12)$$

Having the output of motor in H.P., the output in watts was calculated by multiplying the horsepower by 746, since one horsepower is equivalent to 746 watts. The efficiency of a motor is watts output, divided by the watts input. The power factor of motor is watts input divided by the product of voltage and current. The torque is the force in pounds multiplied by the length of brake arm in feet.

In the second test, the scale and method of following out the experiment was of the same nature as the first experiment, with only one exception. In the first part, the length of brake arm was eight inches, while in the second experiment, a brake arm of three inches in length was used. In the third experiment, the scale was changed from a platform type to a spring balance.

RESULTS.

After calculating efficiency, power factor, and torque, curves were drawn for all three experiments as shown on plates XII, XIII and XIV. The results obtained from the first two experiments checks within one or two per cent. The results obtained with the spring balance differ slightly from those obtained with the platform scale. This is due to the fact that the readings of the spring balance could not be taken as accurate as those obtained with the platform scale. The average efficiency and power factor was rather small. The maximum efficiency obtained in the first two experiments was 46 per cent., while the results gotten by means of the spring balance was 42 per cent. The maximum power factor obtained was about 65 per cent. The maximum output of the motor, in watts, was

found to be 327, while the maximum horsepower output averaged .436. The values of the output in watts, and horsepower checked within one-hundredth of one part. Although the efficiency of the motor is small, this is of little importance, as the power consumed in this case is not very great. Three tests were also made with the motor in order to investigate whether or not it takes more power to drive the motor, when a load is placed upon the rectifier, than without a load. The results show that there is no difference, or a slight difference. The maximum power required to operate the motor was about 150 watts. The maximum current was about four and one half amperes.

A number of tests were made on the low voltage circuit breaker to see when it drops out. At each test the circuit breaker dropped out when the e.m.f. on the alternating current side was about 70 volts.

A number of tests were also performed on the rectifier to determine the effect of a sudden change in voltage on sparking on the commutator. Results showed there was no sparking with change of voltage.

TEST

Of

THE TRANSFORMER.

TEST OF THE TRANSFORMER.

The transformer used in these experiments could be stepped down from 110 or 120 volts to 60, 65, 70, 75 and 80 volts. On the transformer two different tests were made; first by the direct method, and then by the short circuit method.

In the direct method readings of the voltmeter, ammeter and wattmeter, on both sides of the transformer were taken. From the data obtained the product of E and I was calculated, and then dividing the wattmeter readings by EI, the power factor of the transformer was obtained.

$$P = EI \text{ Cos. } \theta \text{ or } \text{Cos } \theta = \frac{P}{EI}$$

By dividing the wattmeter reading of the low tension side by the wattmeter reading of the high tension side, the efficiency was obtained.

In the short circuit method, reading of e.m.f., current and watts were taken when a normal e.m.f. was impressed on the primary, with the secondary open. This gave the no load iron loss in the transformer. The secondary of the transformer was next short circuited, and such an e.m.f. was impressed on the primary so as to give full load current on the primary. As the transformer is rated at about

four kw., the full load current, therefore is, 4000 ÷ 120 = 33.33 amperes. The short circuit tests were repeated for each ratio of transformation. The readings of the wattmeter gave the copper loss. In ordinary tests, after taking the iron and copper losses, the efficiency of the transformer could be calculated directly, as all that would be necessary would be to assume a load EI , and the efficiency would be,

$$\frac{EI - \text{iron loss} - \text{copper loss}}{E\ I}$$

Owing to the fact that the power lost in the resistance wire was included in the wattmeter of the transformer, it was necessary to get the readings of the power loss in the resistance wire separately. The power lost in the resistance wire was then subtracted from the total power, and the efficiency of the transformer was calculated. The results of these calculations are shown on tables VIII and IX, while the curves are indicated on plates XIV, XV, and XVI. The average efficiency is about 90 percent, while the average power factor is about 96 per cent.

THEORY AND CALIBRATION

Of

THERMOCOUPLE.

THEORY & CALIBRATION OF THE THERMOCOUPLE.

In making tests for the rise in temperature of a motor for any period of time, two methods were followed out, - the method by which a thermocouple was used, and by the direct method; that is, with the aid of a thermometer.

THEORY.

The theory of the thermocouple or the thermoelectric thermometer is as follows: When two different metals are joined together in a circuit, as shown in diagram IV, and one junction is heated, an electromotive force is produced which tends to drive a current in a certain direction as shown in the diagram. This electromotive force increases as the difference in temperature between the two junctions increases. Therefore, if a galvanometer is inserted in the circuit, the deflection of the galvanometer will be proportional to the electromotive force, which in turn is proportional to the temperature rise. If the readings of the deflection of the galvanometer in millimeters is calibrated

in terms of the thermometer scale, the rise in temperature can be obtained direct.

In making the thermocouple, two wires were used, - one of copper, and the other of constantine, (an alloy of copper and nickel). The ends of these wires were soldered together, forming two junctions. The calibration of this thermocouple was as follows: One junction was placed in a beaker of ice water, and kept at a constant temperature of zero degrees Centigrade. The other junction was placed in a beaker containing warm water. The temperature of the water in the latter beaker was increased in five degree steps. Before taking the readings, the water was stirred thoroughly, thereby obtaining a uniform temperature throughout. Then readings of the thermometer in degrees Centigrade, and the corresponding deflection of the galvanometer, in millimeters, were observed. From the data obtained, a curve was drawn with readings of the deflection of the galvanometer, in millimeters, as abscissae, and the thermometer readings, in degrees Centigrade, as ordinates. By means of this curve any deflection of the galvanometer can be read off in terms of the temperature in degrees Centigrade.

OSCILLOGRAPH

and

THE WAVE FORMS

OSCILLOGRAPH AND THE WAVE FORMS.

The current and e.m.f. waves were taken with the oscillograph.

THE OSCILLOGRAPH.

An ordinary galvanometer shows no deflection from an alternating current, because the needle system has so much inertia that it cannot follow the rapid impulse from the alternating current. Blondel made a galvanometer with very light moving parts and of high frequency, so that the needle system can follow the change in the alternating currents. A galvanometer with a high frequency needle system, so that its deflections show the variation in alternating currents, is an oscillograph. The oscillograph consists of a narrow loop of pure silver - strip, which is stretched with considerable tension by a spring so as to have a very short natural period of vibration. This is in the strong magnetic field and placed with the plane of the loop parallel to the magnetic field. The strip is thus twisted by the magnetic force when a current passes through the loop. The natural frequency of the loops is commonly from 3000 to 10,000 vibrations per second, so that its deflection can follow very closely all ordinary vibrations in alternating

currents. The deflections are recorded by a beam of light which is reflected from a small mirror attached to the loop. This beam of light falls on a photographic plate which moves at right angles to the deflection. It thus leaves a curve showing the variations of the currents and e.m.f.s.

After connecting up the machine as outlined in the directions, a number of oscillographs of the various machines with different loads were taken, with a view of obtaining a small intimate knowledge of its performance.

WAVE FORMS.

The shape of the e.m.f. curve of an alternator depends upon the shape and distance apart of the pole pieces of the field magnet, and upon the distribution of the armature winding.

Whenever a band of armature wires are cutting a uniformly distributed flux under the pole pieces, the resulting e.m.f. will be one of a straight line with a flat top.

When an alternating electromotive force acts upon a circuit which contains resistance only, that is, a circuit which has a negligibly small inductance and which does not include a condenser, the current

curve is exactly the same shape as the e.m.f. curve, inasmuch as the current is equal at each instant, to the e.m.f. divided by the resistance.

The wave forms of this rectifier are shown in figures I to VIII inclusive. The first two figures show the wave forms of e.m.f. and current with a generator that gives an approximate sine wave. Figures III and IV show the wave form with a sine wave generator as a prime mover.

Fig. V shows the wave forms with peaked wave generator as a prime mover. Figure VI shows the wave forms with the same generator, but in this case a different load was used. The last two figures show the wave forms with an arc light as load. In all these oscillograms the current seems to be in phase with the electromotive force.

EXPLANATION

of

DIAGRAMS, TABLES AND CURVES

DIAGRAMS.

Diagram I shows the front view and complete rear wiring of the switchboard for the Mechanical Rectifier. Upon the switchboard is placed the following: a resistance wire, lamp, polarity switch, low voltage circuit breaker, transformer and the motor. The wiring of this switchboard is as shown in the diagram.

The alternating current supply starts from the generator and leads directly to the upper switch of the board. From the switch it branches off as follows:- two leads are connected to the motor, while the next two are connected to the transformer. In the reversing switch, the upper wire of one side of the switch is connected to the lower part of the other, while the lower side is connected to the upper part of the other side of the reversing switch. One side of the central point of the switch is connected to the ammeter, while three wires go to the following places:- one to the low voltage circuit breaker; the second to the small lamp, while the third is connected to the direct-

current side of the outgoing line. From the ammeter another wire leads to the direct-current side of the outgoing line, while one is connected to the circuit breaker; the second to the lamp and a third to the outgoing direct-current line. From the resistance wire one wire leads to a brush of the motor, while the other side of the resistance leads to the second side of the circuit breaker. The second brush of the motor is connected to the primary of the transformer, while the third and fourth brushes are connected to the opposite sides of the reversing switches. From all the tap of the transformer is connected a wire directly to the circuit breaker, for the purposes of making a circuit between any of the transformations.

Diagram II shows the complete wiring diagram, a scheme of connections for performing the various tests of the rectifier. From the generator two leads are connected to points 1 and 2 on the selector switch. From the opposite points of the selector switch there are two wires leading to the alternating-current switch of the rectifier. From the direct-current switch of the rectifier, there are two

wires which lead back to points 5 and 6 of the selector switch and from the other side of the switch there are connections made to lamp rack. The ammeter and wattmeter are both connected in series to two points on the selector switch. These two points are connected to the selector switch in such a way that the readings of the instruments are indicated for the direct-current as well as alternating-current side. The voltmeter and frequency meter are connected directly to the potential posts.

Diagram III shows the connections for measuring power in a resistance wire. The ammeter and the current coil of the wattmeter are connected in series with the resistance wire, while the potential plugs of the wattmeter are connected to the opposite side of the resistance wire. A lamp rack is also connected on one side of the line in order to obtain any low current which may be desired.

TABLES.

Table I. shows the data of the calibration of the voltmeter, ammeter, and wattmeter. Column one gives the correct readings of the standard instruments, while columns two and three indicate the readings of the instruments which were calibrated. Two sets of data were taken for each instrument, and the average of the two readings was tabulated as shown in column four. Column five gives the actual error in volts, amperes and watts. Column six indicates the per cent. error.

Table II. shows the data for the calibration of the thermocouple. Column one indicates the deflection of the galvanometer in millimeters. Column two shows the corresponding readings of the thermometer in degrees Centigrade.

Table III. shows the data and calculations for efficiency, and power factor of the rectifier, with approximate sine wave generator, using the arc lamp as load. The first three columns give the readings of voltage, current, and watts for the alternating-current side of the rectifier, while the next three columns of E, I, and W, for the direct-current side

of the rectifier. Column seven indicates the product of the impressed alternating-current voltage or EI. Columns eight and nine show the results of percentage power factor and per cent. efficiency. Column ten indicates the number of cycles of the prime mover which was kept constant at sixty cycles.

Tables IV. and V. are of the same order as the preceding table, with the exception of the wave form of the generators used. A generator giving a peaked wave was used in obtaining the data as shown in table IV., while a generator giving a sine wave was used in obtaining the data shown in table V. In both cases lamp racks, and resistance boxes were used as loads.

Table. VI. shows three sets of data and calculations of the rectifier, using an approximate sine wave generator. The first set of data was taken when the arc lamp was used as load, the second set of data was observed when an induction motor was inserted in parallel with the generator. The third set of data was taken when the load was short-circuited for a short period of time.

Table VII. is composed of two sets of data and calculations for tests of motor. The first three columns indicate the instrument readings of E, I, and W. The fourth column shows results in pounds as indicated by the platform scale.

Column five indicates the products of voltage and current. Column six indicates the horsepower output of motor, while column seven shows the output of the motor in watts. Column eight and nine indicates the results of the per cent. efficiency and per cent power factor. The last column in the above table indicates the torque in pound feet.

Table VIII. corresponds to the preceding table with the exception that a spring balance was used in obtaining the weight.

Table IX. This table shows the data and calculations for the transformer by the direct method. The first three columns indicate E, I, and W of the primary side of the transformer, while the next three columns show the readings of E, I, and W as obtained on the secondary of the transformer. Column seven indicates the product of E and I of the primary side,

while the last two columns show the final results of the per cent. efficiency and per cent. power factor.

Table X. is similar to that of table nine, but in this table the data was obtained by the method of losses.

Table Xl. shows the watts lost in the resistance wire for various loads. All of the voltmeter readings are not tabulated, as they are unnecessary for obtaining the results desired.

Table XII. shows the rise in temperature of the motor for two different periods, at intervals of about one hour. The thermometer readings were obtained by placing the thermometer in contact with the yoke of the motor, while the thermocouple readings were taken for the inside part of the motor.

CURVES.

Plates I, II, and III show the calibration curves of the voltmeter, ammeter and wattmeter respectively. The true readings of the standard instruments were plotted as the abscissae, while the readings of the instruments, used in performing these experiments, were plotted as the ordinates.

Plate IV shows the calibration of the thermocouple, with deflection of the galvanometer, in millimeters,as abscissae, and the corresponding readings of the thermometer, in degrees Centigrade, as the ordinate.

Plates V and VI show the efficiency and power factor curves for the Mechanical Rectifier with an approximate sine wave generator. Five curves were drawn for the five ratios of voltage transformations as obtained from table three. The curves are indicated by the letters A, B, C, D and E.

Curve A indicates the ratio of transformation of 120 to 60 volts.

Curve B, the ratio of 120 to 65.

Curve C, " " " 120 " 70.

Curve D, " " " 120 " 75.

Curve E, " " " 120 " 80.

The load in amperes was plotted as the abscissa, while the per cent. efficiency and power factor as ordinates.

Plates VII, VIII, IX, and X are similar to V and VI, with the exception that the curves on the plateVII, and VIII were plotted for the data obtained with the peaked wave generator as the prime mover, and the curves on the plate IX and X were plotted for the data obtained with the sine wave generator as prime mover.

Plates XI, XIII and XIII show the curves for per cent. efficiency, per cent. power factor, and torque in pound feet for the motor. The output of the motor, in watts, was plotted as the abscissae, while the per cent. efficiency, per cent. power factor, and torque in pound feet as ordinates. Plate XI represents the curves drawn for the prony brake test

of the motor, using a platform scale and brake arm of eight inches in length. In the following plate the same scale was used, but the brake arm was changed to three inches in length. In plate XIII, the same brake arm of three inches was used but a spring balance was used instead of a platform scale.

Plates XIV, XV, XVI, were drawn for the data obtained in the tests of the transformer. In this test data was also obtained for the various ratio of transformation, and efficiency and power factor curves were plotted. Each curve is specified by the letters A, B, C, D and E, the meaning of which has been explained in the curves for the rectifier. The loads in amperes were plotted as abscissae, while the ordinates represented the per cent. efficiency, and power factor. The curves on plate XIV and XV were drawn from data obtained by the direct method, while in plate XVI the curves were drawn from the data obtained by the method of losses.

Plate XVII shows the curve representing the watts lost in the resistance wire for various loads, in amperes. The loads in amperes were plotted as abscissae, while the I^2R loss, in watts, as the ordinates.

Plate XVIII shows the curves for the rise in temperature in the motor taken at different periods. Curves I and II are for the results obtained with the thermometer, while curves III and IV are for the results obtained with the thermocouple. The time, in hours, was plotted as abscissae, while the rise in temperature, in degrees Centigrade was plotted as ordinates.

C O N C L U S I O N

CONCLUSION.

After performing several experiments with the rectifier, we came to the conclusion that this rectifier is as good or better than the average rectifier placed on the market, for the following reasons: the efficiency of the rectifier itself is as high as any of the rectifiers now being used. The power factor approaches very nearly unity. The floor space occupied by this rectifier is very small. The only difficulty encountered with it was in overcoming the sparking of the brushes when an overload was placed on the rectifier. There is no doubt whatever that this difficulty will soon be eliminated through some slight changes, and this rectifier will be the one that will be used to a great extent in the moving picture industry.

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Table I.

Data for Calibration of Instruments.

W Std.	W_r.	W_l.	W Average	Error Watts	Percent. Error
		Wattmeter.			
1100	1090	1100	1095	5	.45
2200	2187	2200	2193	7	.318
3300	3300	3300	3300	0	.000
4400	4400	4400	4400	0	.000
5500	5500	5500	5500	0	.000
		Ammeter.			
A Std.	A_r.	A_l.	A Average	Error in Amp.	Percent. Error.
8	7.9	7.9	7.9	.1	1.2
12.0	11.8	11.8	11.8	.2	1.6
16.0	15.8	15.85	15.82	.18	1.12
20.0	19.9	19.85	19.87	.13	.65
24.0	24.	23.85	23.93	.07	.29
28.0	27.8	27.90	27.85	.15	.525
32.0	31.8	31.85	31.825	.175	.535
36.0	35.8	35.85	35.82	.18	.486
40.0	39.8	39.85	39.82	.18	.437
44.0	43.8	43.85	43.82	.18	.397
48.0	48.0	48.0	48.00	0	0
52.0	52.0	52.0	52.00	0	0

Voltmeter.

V Std.	V Read.	V_2	V aver.	Error	V Std.	V Read.	V_2	V aver.	Error
10	9.9	10.3	10.1	.1	70	70.1	70.5	70.3	.3
20	20.3	19.9	20.1	.1	80	80.2	80.2	80.2	.2
30	29.9	30.5	30.2	.2	90	90.4	90.1	90.25	.25
40	39.9	40	39.95	.025	100	100	100.5	100.25	.25
50	49.8	50.2	50.0	.0	110	110.5	109.8	110.15	.15
60	59.9	60.3	60.1	.15	120	120.6	119.8	120.2	.2

Table II.

Calibration of Galvanometer

for Thermo - Couple.

Deflection of Galvanometer in mm.	Corresponding degrees in Centigrade.	Deflection of Galvanometer in mm.	Corresponding degrees in Centigrade.
10	3.05	150	42.95
20	6.0	160	465
30	9.0	170	50.3
40	12.1	180	53.3
50	15.0	190	56.0
60	18.	200	59.0
70	20.85	210	62.0
80	23.	220	65.0
90	26.3	230	68.0
100	29.0	240	71.0
110	31.9	250	74.0
120	34.8	260	76.8
130	37.0	270	80.0
140	40.0	280	83.0

Table III.

Data and Calculation of Rectifier with Approximate Sine Wave Generator Using Arc Lamp as Load.

$I_{a.c.}$	$E_{a.c.}$	$W_{a.c.}$	$I_{d.c.}$	$E_{d.c.}$	$W_{d.c.}$	E x I	% PF	% Eff.	F cycle
				Ratio of Transformation 110-60					
20.0	110	1420	17.10	47.0	745	2200	64.5	52.5	60
21.8	110	1600	26.25	38.5	985	2400	67.0	61.5	60
26.3	110	1900	39.00	25.0	960	2920	72.25	50.6	60
30.5	111	2425	45.00	19.5	900	3385	72.00	37.1	60
31.5	111	2520	47.50	13.0	770	3500	72.00	30.55	60
				Ratio of Transformation 110-70					
14.5	111	800	10.00	62.2	620	1610	49.8	77.50	60
17.5	108.5	1275	18.5	53.0	980	1900	66.35	77.00	60
24.25	110.8	1880	29.0	45.0	1320	2658	70.00	70.50	60
26.3	109.5	2125	34.0	39.5	1348	2910	73.20	69.70	60
32.8	112.5	2700	42.5	31.0	1380	3710	73.00	73.00	60
34.5	110.5	2750	46.0	24.0	1230	3820	72.00	72.00	60
				Ratio of Transformation 110-80					
15.75	110.0	960	13.0	70.0	830	1727	54.4	72.2	60
17.00	110.0	1085	15.5	67.5	950	1870	58.0	72.2	60
20.25	110.0	1400	20.4	62.5	1220	2227	62.8	69.00	60
26.30	110.5	2000	29.5	54.0	1540	2905	69.9	62.85	60
33.30	110.5	2650	39.0	44.0	1690	3680	72.0	58.20	60
39.50	111.5	3175	45.0	37.0	1640	4400	72.15	56.0	60

Table IV.

Data and Calculation of Rectifier with Peaked Wave Generator Using Lamp Rack as Load.

$E_{a.c.}$	$I_{a.c.}$	$W_{a.c.}$	$E_{d.c.}$	$I_{d.c.}$	$W_{d.c.}$	IE	Eff.	P.F.	F cycles
				Ratio of Transformation 120-60					
119.0	6.0	250.0	0.0	0.0	0.0	714	0.0	35.0	60
118.0	15.6	1650.0	72.0	15.8	600	1865	36.4	90.5	60
122.0	24.4	2720.0	62.8	28.0	1780	2978	65.5	91.0	60
123.0	30.8	3650.0	53.5	37.4	2000	3790	56.3	93.5	60
120.0	42.4	4950.0	35.0	53.0	1900	5080	38.5	97.0	60
				Ratio of Transformation 120-65					
120.5	6.5	225.0	0.0	0.0	0.0	784	0.0	28.75	60
124.0	19.8	2275.0	70.5	22.0	1528	2460	66.6	92.50	60
120.0	26.6	3175.0	51.0	31.0	1625	3190	62.3	99.0	60
123.0	40.0	4750.0	37.5	53.0	1950	4920	41.2	96.5	60
				Ratio of Transformation 120-70					
118.0	6.5	300.0	0.0	0.0	0.0	769	0.0	37.9	60
121.0	22.0	2500.0	61.0	26.8	1575	2660	63.0	93.85	60
119.5	31.0	3575.0	42.5	41.0	1700	3710	48.0	96.20	60
122.0	39.0	4600.0	32.5	52.8	1700	4760	37.0	96.90	60
				Ratio of Transformation 120-75					
121.5	6.8	300.0	0.0	0.0	0.0	820	0.0	36.20	60
122.0	22.2	2500.0	53.5	27.6	1500	2706	60.0	91.75	60
122.5	30.2	3675.0	39.5	41.6	1650	3700	44.8	99.0	60
116.5	36.0	4050.0	28.5	49.2	1425	4200	35.2	96.6	60
				Ratio of Transformation 120-80					
120.0	7.2	325.0	79.5	0.0	0.0	864	0.0	39.75	60
120.0	20.8	2325.0	54.5	25.4	1400	2490	61.4	93.3	60
122.0	30.0	3475.0	41.0	40.8	1600	3000	46.0	95.0	60
120.0	35.0	4000.0	28.5	48.6	1400	4275	35.0	95.8	60

Table V.

Data and Calculation of Rectifier with Sine Wave Generator using Lamp Rack as Load.

$I_{a.c.}$	$E_{a.c.}$	$W_{a.c.}$	$I_{d.c.}$	$E_{d.c.}$	$W_{d.c.}$	IE	% P.F.	% Eff.	F cycles
				Ratio of Transformation 120-60					
8.2	122.5	380	00.0	112.5	1000	998.0	38.02	00.0	60
16.0	120.0	1700	15.6	83.5	1175	1922	88.25	69.0	60
20.6	120.5	2250	24.8	76.0	1490	2482	90.75	66.2	60
26.5	120.2	3025	31.0	64.0	1825	3200	94.60	58.7	60
35.75	120.0	4187	45.0	44.5	2025	4300	95.40	48.4	60
				Ratio of Transformation 120-65					
8.0	122.0	7.2 x 50	00.0	100.0	000	975	37.0	00.0	60
12.2	120.0	24.0 "	10.0	99.0	800	1462	82.0	66.6	60
20.2	120.0	45.5 "	26.6	74.0	1485	2412	94.5	65.2	60
28.2	120.0	65.5 "	34.7	57.5	1840	3380	96.8	54.7	60
34.8	120.5	82.0 "	43.8	45.0	1900	4200	97.6	46.8	60
				Ratio of Transformation 120-70					
7.0	120.0	337.5	00.0	96.5	0000	840	40.2	00.0	60
14.2	120.0	1650	16.4	78.0	1125	1705	96.6	68.25	60
21.8	120.0	2500	26.0	65.0	1550	2498	95.6	62.25	60
32.0	120.0	3725	33.8	44.9	1735	3840	96.8	46.60	60
				Ratio of Transformation 120-75					
7.0	120.0	325	00.0	72.0	000	840	38.7	00.0	60
17.0	120.0	1400	20.0	58.0	1250	2040	94.75	66.0	60
20.7	120.0	2350	25.5	53.0	1475	2483	94.7	62.7	60
30.2	120.0	3525	40.15	41.0	1675	3620	97.25	47.6	60
				Ratio of Transformation 120-80					
7.0	120.0	375.0	00.0	69.0	000	840	38.7	00.0	60
16.4	120.2	1775	18.5	56.5	1175	1970	90.0	66.3	60
20.2	120.5	2270	25.6	50.5	1375	2430	92.6	61.2	60
29.0	120.0	3375	39.6	38.5	1550	3480	97.0	45.8	60
				Arc. Lamp as Load.					
23.0	122.0	255	25.0	62.0	1725	2810	91.0	69.7	60
28.6	121.0	3325	34.2	54.0	197.5	3470	96.0	59.4	60

Table VI.

Data and Calculation of Rectifier Under Various lists.

$I_{a.c.}$	$E_{a.c.}$	$W_{a.c.}$	$I_{d.c.}$	$E_{d.c.}$	$W_{d.c.}$	% Eff.	% P.F.	f cycles	EI
				Using Arc Lamp as Load.					
29.4	118	3080	40.39	40	1600	52.	88.8	60	3465
36.2	120	3950	42.5	47	1875	47.50	91.0	60	4340
42.0	120	4600	50.8	39	1675	36.5	91.2	60	5040
52.6	119	6000	....	..	....	....	95.8	60	6260

When an Induction Motor was inserted in Parallel with the generator, the following results were obtained:

I.	E.	W.	F cycles	P.F.
17.1	120.6	1870	60	90.8
16.9	120.0	1820	60	90.0

When load was short circuited for about 5 min. the following results were obtained:

I.	E.	W.	EI	P.F.
121.6	40	4800	4860	98.9
121	38	4700	4690	99.8

Table VII.

Data and Calculations for Motor of Rectifier

E	I.	W.	P.	E.I.	P.F.	Output H.P.	Output in watts	Eff.	Ft.Lbs. Torque	RPM.
Brake Arm 8" - Net Wt. 4.58 lbs. Platform Scale.										
122.0	5.25	150	4.64	640	23.45	.0137	10.2	6.8	.106	1800
118.0	7.9	325	5.00	933	34.8	.1415	105.5	32.5	.28	1800
119.0	7.95	425	5.5	945	45.0	.211	157.0	37.0	.614	1800
118.0	8.30	550	6.0	980	56.0	.325	250	45.4	1.09	1800
120.5	8.90	650	6.25	1092	57.25	.382	284		1.28	1800
Brake Arm 3" - Net Wt. 4.34 lbs. Platform Scale.										
121.0	5.1	150	4.75	615	23.40	.0366	27.3	....	.102	1800
121.0	5.2	175	5.00	628	27.90	.0588	53.8	30.7	.165	1800
120.5	5.38	200	5.25	648	30.9	.0812	60.5	30.8	.23	1800
120.5	5.6	225	5.50	673	33.5	.1038	77.35	30.8	.29	1800
120.3	5.9	250	5.75	710	35.25	.1302	92.15	31.2	.36	1800
118.0	7.65	375	6.00	885	42.45	.148	110.2	31.5	.415	1800
117.5	7.7	400	6.25	905	44.3	.1705	127.0	31.8	.475	1800
118.5	7.4	400	6.50	870	45.6	.1925	143.5	35.9	.570	1800
118.5	7.45	425	6.75	883	48.20	.215	160.0	37.6	.60	1800
118.0	7.6	450	7.00	897	50.2	.2370	177.0	39.3	.665	1800
118.0	7.8	475	7.25	895.	52.9	.2580	192.4	40.5	.73	1800
118.0	7.9	500	7.50	920	54.4	.287	210.3	42.10	.79	1800
118.0	8.05	525	7.75	93.2	56.25	.304	226.3	43.15	.85	1800
118.0	8.20	550	8.00	950	58.0	.327	243.7	44.25	.914	1800
118.0	7.6	580	8.25	968	59.9	.349	266.0	44.80	.98	1800
117.0	8.38	600	8.50	974	61.6	.357	266.0	44.40	.98	1800
110.0	9.20	700	9.00	1010	69.35	.438	327.0	46.65	1.05	1800

Table VIII.

Data & Calculation for Motor of Rectifier.

E	I.	W.	P.	EI.	% P.F.	H.P.	Output in watts	Eff.	Torque	RPM.
				Brake Arm 3" - Spring Balance.						
123.5	4.8	150	.25	593	25.25	.0222	15.8	10.52	.062	1800
122.8	5.0	180	.50	613	29.5	.0446	33.3	18.45	..125	1800
122.3	5.0	200	.75	612	32.7	.0668	49.8	19.8	.187	1800
122.3	5.2	225	1.00	636	35.38	.0890	66.4	29.5	.250	1800
121.5	5.4	250	1.25	657	38.10	.1125	82.0	32.75	.312	1800
119.5	7.4	375	1.50	885	43.8	.1337	99.5	26.50	.375	1800
119.5	7.4	390	1.75	885	44.15	.156	116.4	29.85	.431	1800
119.5	7.5	410	2.00	897	45.60	.178	132.8	32.4	.500	1800
119.5	7.6	440	2.25	909	48.25	.202	149.5	34.0	.562	1800
119.5	7.7	475	2.50	921	51.60	.222	165.5	34.8	.624	1800
119.5	7.8	500	2.75	932.5	53.60	.245	183.0	36.6	.688	1800
119.5	7.9	525	3.00	945	55.5	.267	199.0	37.9	.750	1800
119.5	8.0	550	3.25	957	57.5	.289	225.5	41.0	.812	1800
119.5	8.1	558	3.50	968	57.7	.312	232.7	41.7	.874	1800
119.5	8.3	600	3.75	992	60.5	.334	249.	41.5	.935	1800
119.5	8.6	650	4.00	1028	63.5	.356	273.	42.2	1.00	1800

Table IX.

Data and Calculation of Transformer by Direct Method.

I_p	E_p	W_p	I_s	E_s	W_s	EI.	W_w	W_w+W_s	% P.F.	% Eff.
				Ratio of Transformation 120-60						
4.2	121.5	25	0.	90	0	511	0	0	4.9	000
4.5	120.5	210	1.5	88	175	542.5	10	185	38.8	90
14.7	120.0	1625	18.2	73.5	1325	1765	200	1525	93.0	94
25.9	121.0	3025	30.8	60	1900	3140	700	2600	96.5	90.4
33.8	120.0	4050	44.5	48	2125	4060	1350	3775	99.6	94.2
36.2	119.5	4300	47.6	41	1954	4325	1950	3900	99.5	91.2
				Ratio of Transformation 120-65						
4.0	120.0	25	0.	97	0	480	0	0	5.2	0
8.0	121.0	850	8.8	80.5	750	960	50	800	88.5	94
23.8	122.0	2825	30.8	60.5	1925	2905	700	2625	98.5	92
31.8	120.0	3750	42.8	45.0	1950	3820	1480	3430	98.2	91.5
33.8	120.0	3975	45.2	41.0	1850	4060	1710	3560	98.2	89.3
				Ratio of Transformation 120-70						
4.0	120.0	25	0	100	0	480	0	0	.52	0
15.5	120.0	1780	21.0	65	1325	1860	300	1625	95.6	91.3
24.1	121.0	2850	33.4	55	1825	2920	860	2685	97.6	92.0
29.6	120.0	3475	41.0	44.5	1775	3550	1360	3135	98.0	91.0
33.0	121.0	3950	46.0	40	1825	3995	1765	3590	99.0	90.1
				Ratio of Transformation 120-75						
3.9	122.0	20	0	100	0	476	0	0	4.2	0
17.9	120.0	2080	25	59	1525	2150	530	2055	96.75	92.0
2.5	120.0	2960	35.6	49	1730	3000	960	2690	98.6	88.0
2.8	120.0	3300	40.0	42	1700	3360	1270	2970	98.25	90.0
30.5	120.0	3500	42.6	38	1575	3660	1475	3050	97.5	87.3
				Ratio of Transformation 120-80						
3.8	120.0	22.5	0	100	0	456	0	0	4.95	0
12.3	120.0	1375	11.8	62	1025	1475	90	1115	93.25	81.5
	120.0	2740	34.2	76.5	1575	2800	890	2465	97.80	90.0
	121.0	3550	43.2	37	1625	3570	1520	3145	99.4	88.7

Table X.

Test of Transformer by Short Circuit Method.

Load EI corresponding to data taken by Direct Method.

EI	I_p	E_p	Watts Lost in Resist. Wire.	Eff.
Ratio of Transformation 120-60				
511	4.2	121.5	120	92
542.5	4.5	120.3	15	88.3
1765	14.7	120.0	162	86.6
3140	25.9	121.0	505	83.5
4060	35.8	120.0	960	82.0
4325	36.2	119.5	975	
Ratio of Transformation 120-65				
480	4.0	120.0	14.5	91.5
960	8.0	121.0	33.3	90.0
2905	23.0	122.0	298.0	89.8
3820	31.8	120.0	532.0	88.5
4060	33.8	120.0	585.0	86.75
Ratio of Transformation 120-70.				
480	4.0	120.0	10.5	91.5
1860	15.5	120.0	88.5	94.0
2920	24.1	121.0	215.0	92.3
3550	29.6	120.0	324.0	90.2
3995	330	121.0	400.0	90.0
Ratio of Transformation 120-75				
476	3.9	122.0	298	93.25
2150	17.9	120.0	72.5	95.0
3000	25.0	120.0	142	94.2
3360	28.0	120.0	178	94.1
3660	30.5	120.0	215	94.0
Ratio of Transformation 120-80				
456	3.8	120.0	2.0	93.5
1475	12.3	120.0	20.4	96.0
2800	23.3	120.0	74.5	96.0
3570	29.5	121.0	120.0	96.0

DATA

No Load Iron Loss

E	I	W
121.5	31	31.0

Copper Loss.

Ratio of Transformation 120-80

I_p	E	W	Loss in Wire.	Copper Loss in Trans. W_t.
3330	72	2375	1650	825
Ratio of Transformation 120-75				
3330	69.5	2275	1700	575
Ratio of Transformation 120-70				
3330	66.5	2175	1770	405
Ratio of Transformation 120-65				
3330	62.5	2050	1800	250
Ratio of Transformation 120-60				
3330	59.5	1970	1850	120

Table XI.

Data of Watts Lost in Resistance Wire for Various Currents.

I.	E.	W.
4	....	12.50
6.5	....	35.00
8.9	....	50.00
11.0	....	75.00
12.25	....	90.00
17.80	....	210.0
23.10	16	362.5
26.5	19	500.0
30.30	23	675.0
35.20	28	975.0
37.70	315	1150.00
41.00	....	1375.0
43.70	38	1625.0
52.00	47	2337.0

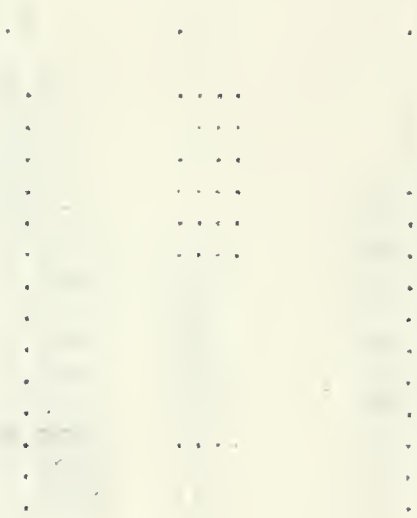
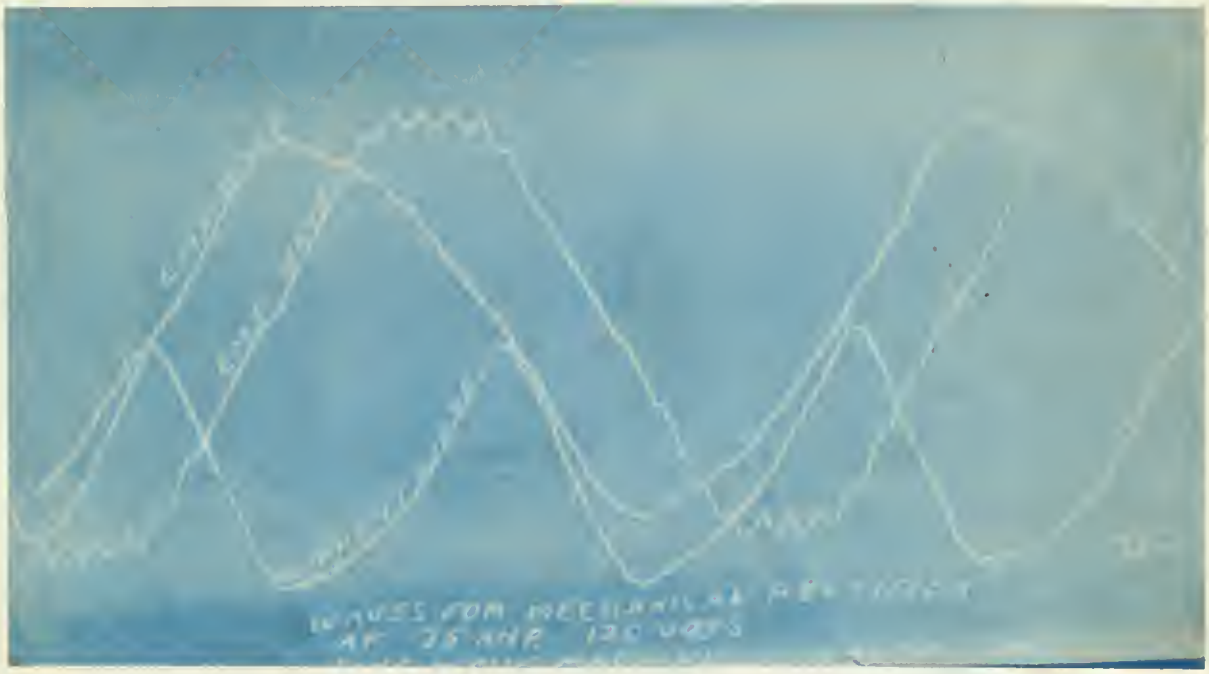
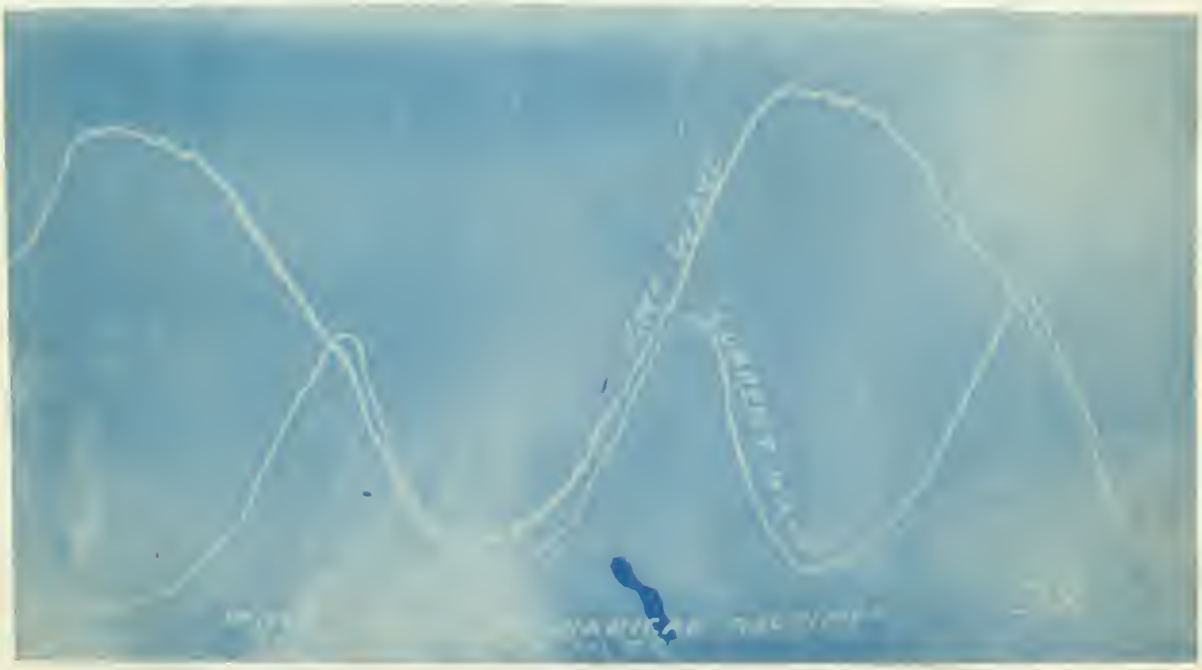


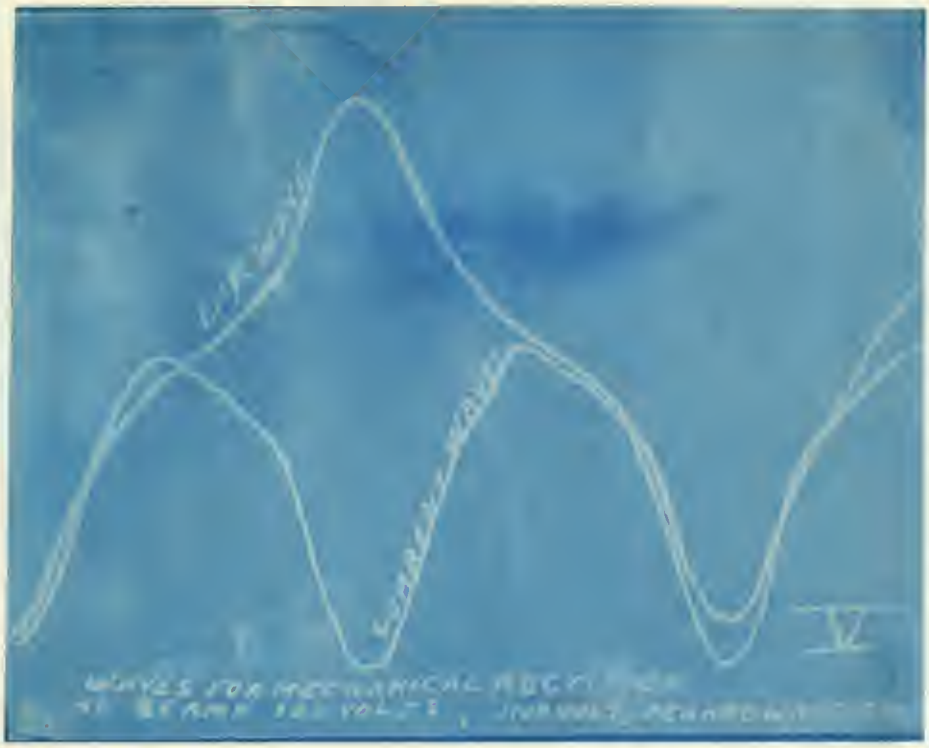
Table XII.

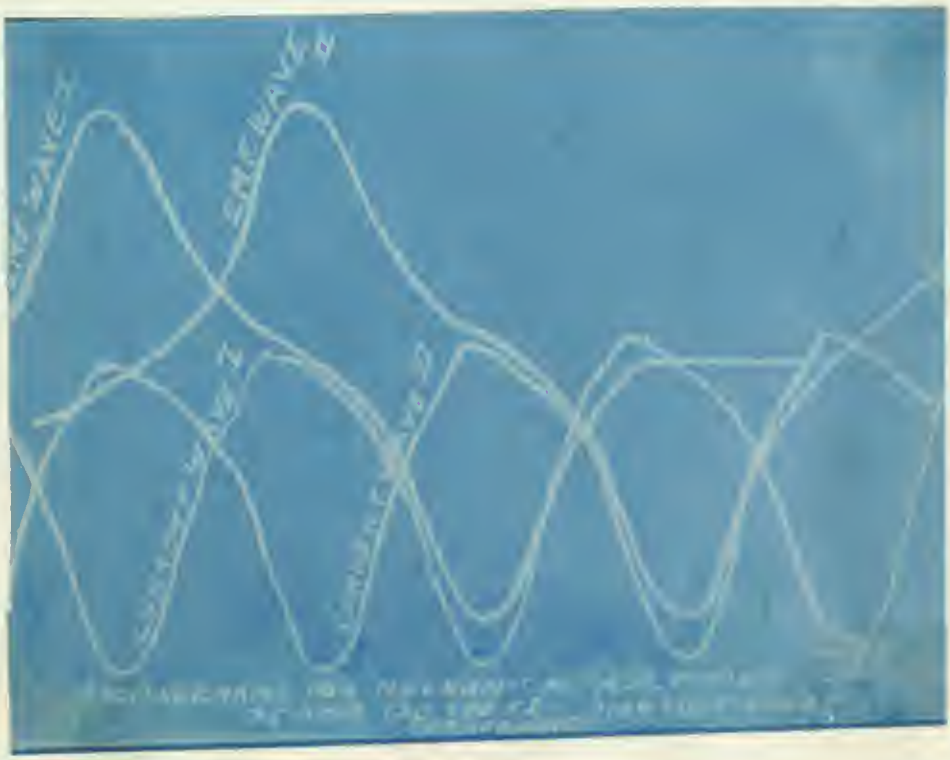
Rise of Temperature of Motor On Surface of Yoke and Inside of Motor.

Test No.1	Time in hours	Thermometer Reading	Thermo-Couple reading in		Room Temp.
			m.m.	Deg.	
"	0	20°C.	---	20°C	20°C.
"	1	50°C.	156	45°	"
"	2	54°	196	57°	"
"	3	56°	230	69°	"
"	4	59°	247	74.5°	"
"	5	63°	255	77.0°	"
No. 2	0	22°	---	22°C.	22°C.
"	1	38°	196	57°	"
"	2	50°	220	65.8°	"
"	3	58°	230	68.8°	"
"	4	63°	238	71.6°	"
"	5	65°	247	74.0°	"









Oscillograms of Current and e.m.f. Wave for Rectifier with Arc Light as Load.

DIAGRAM No I

FRONT ELEVATION AND REAR WIRING DIAGRAM OF
MECHANICAL RECTIFIER.

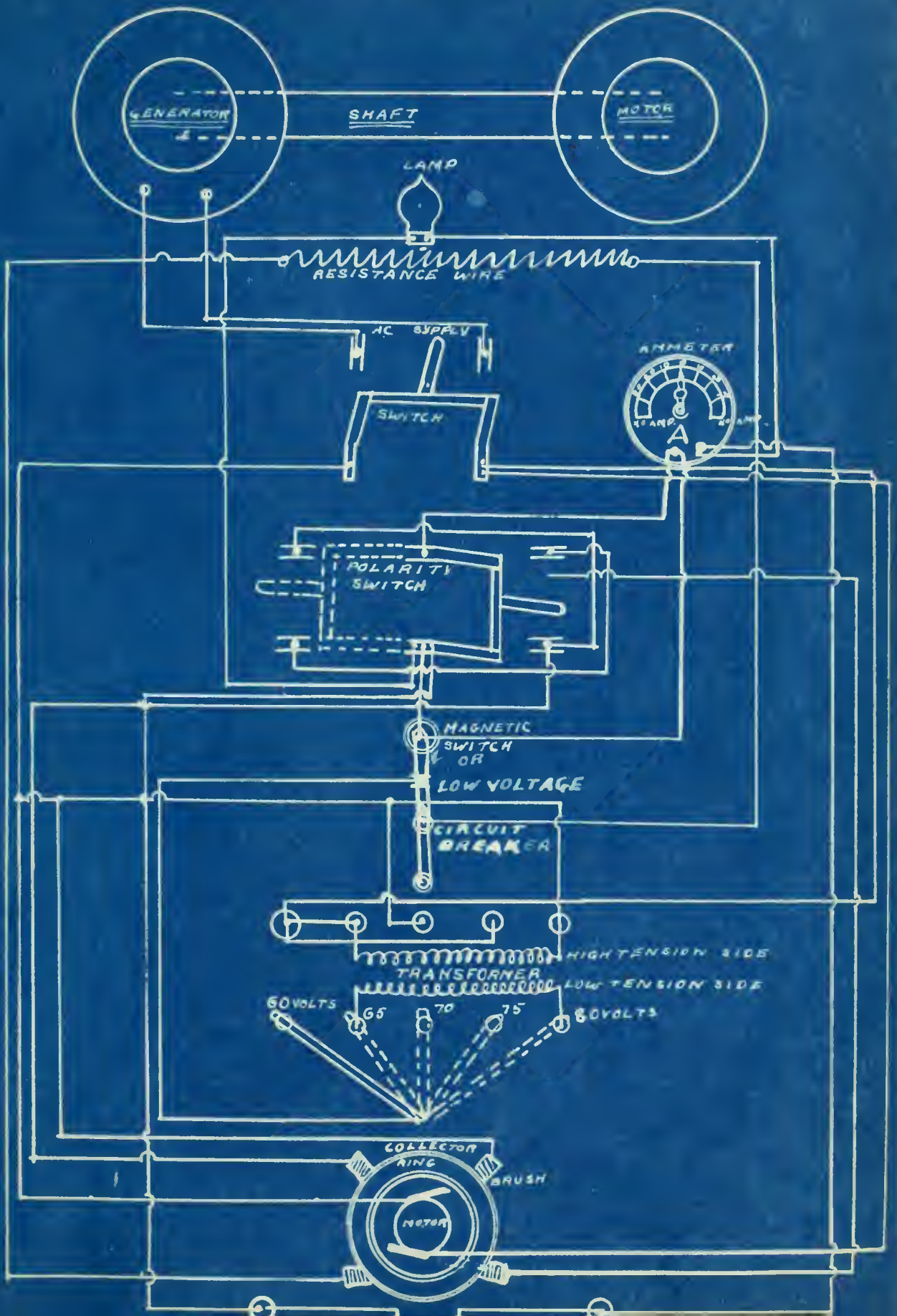


DIAGRAM No II

SCHEME OF CONNECTIOS FOR RECTIFIER TESTS

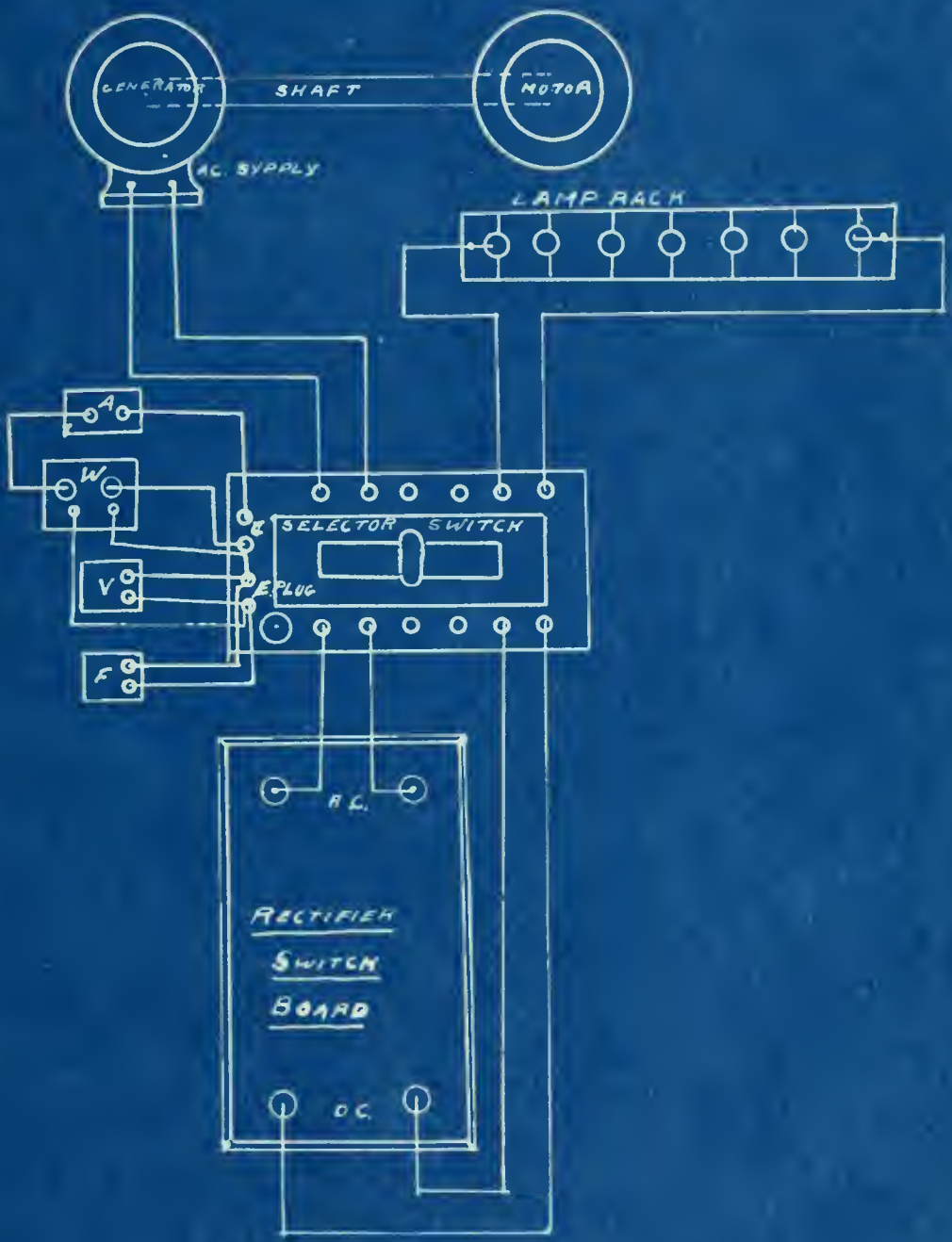


DIAGRAM No III

CONNECTIONS FOR TEST IN MEASURING LOSS OF POWER IN RESISTANCE COIL.

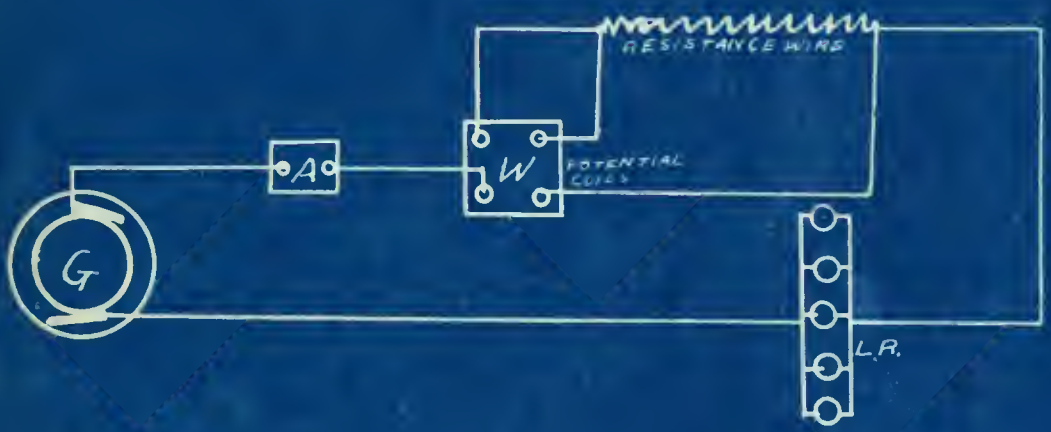


PLATE I.

CALIBRATION OF VOLTMETER.

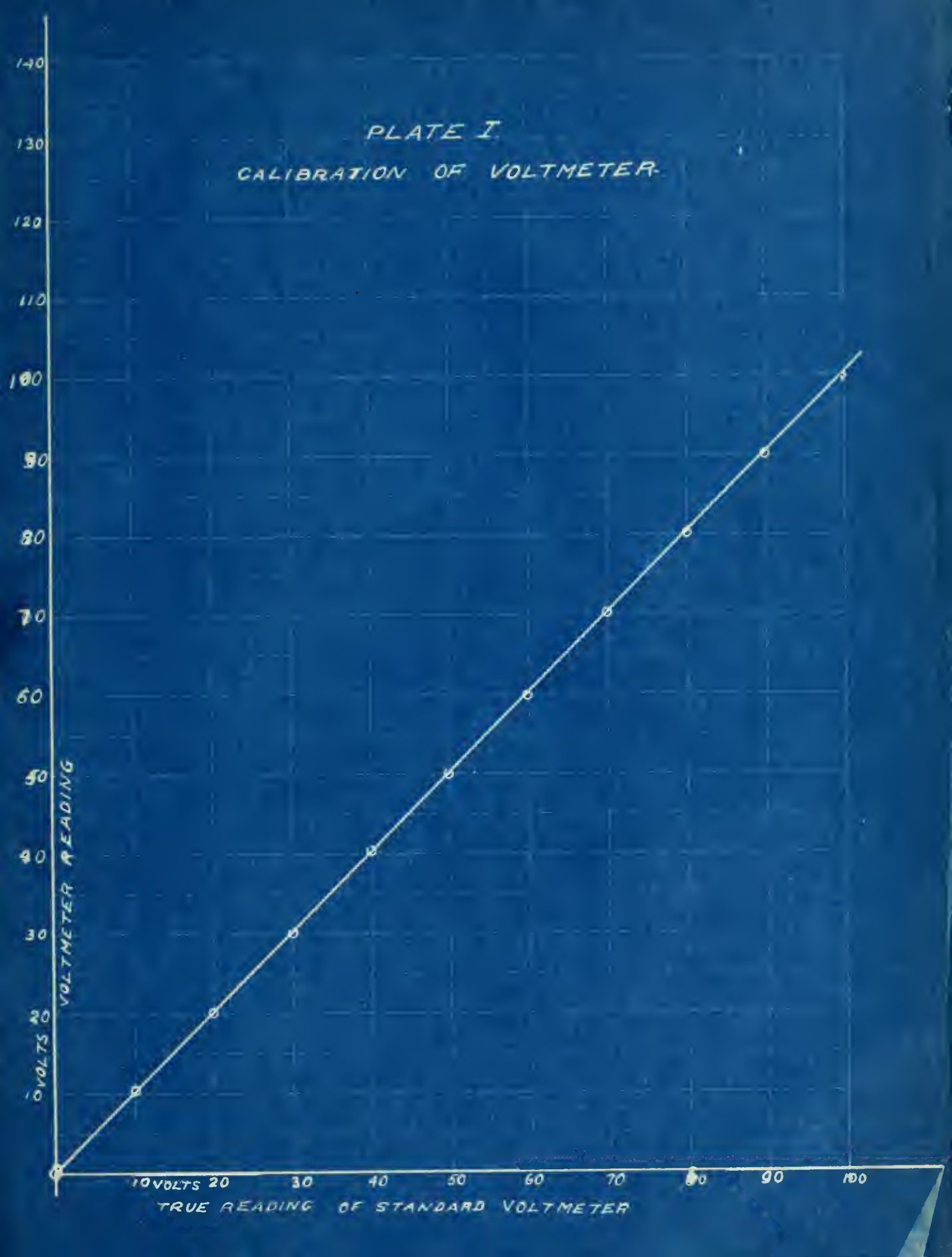


PLATE II

CALIBRATION OF AMMETER

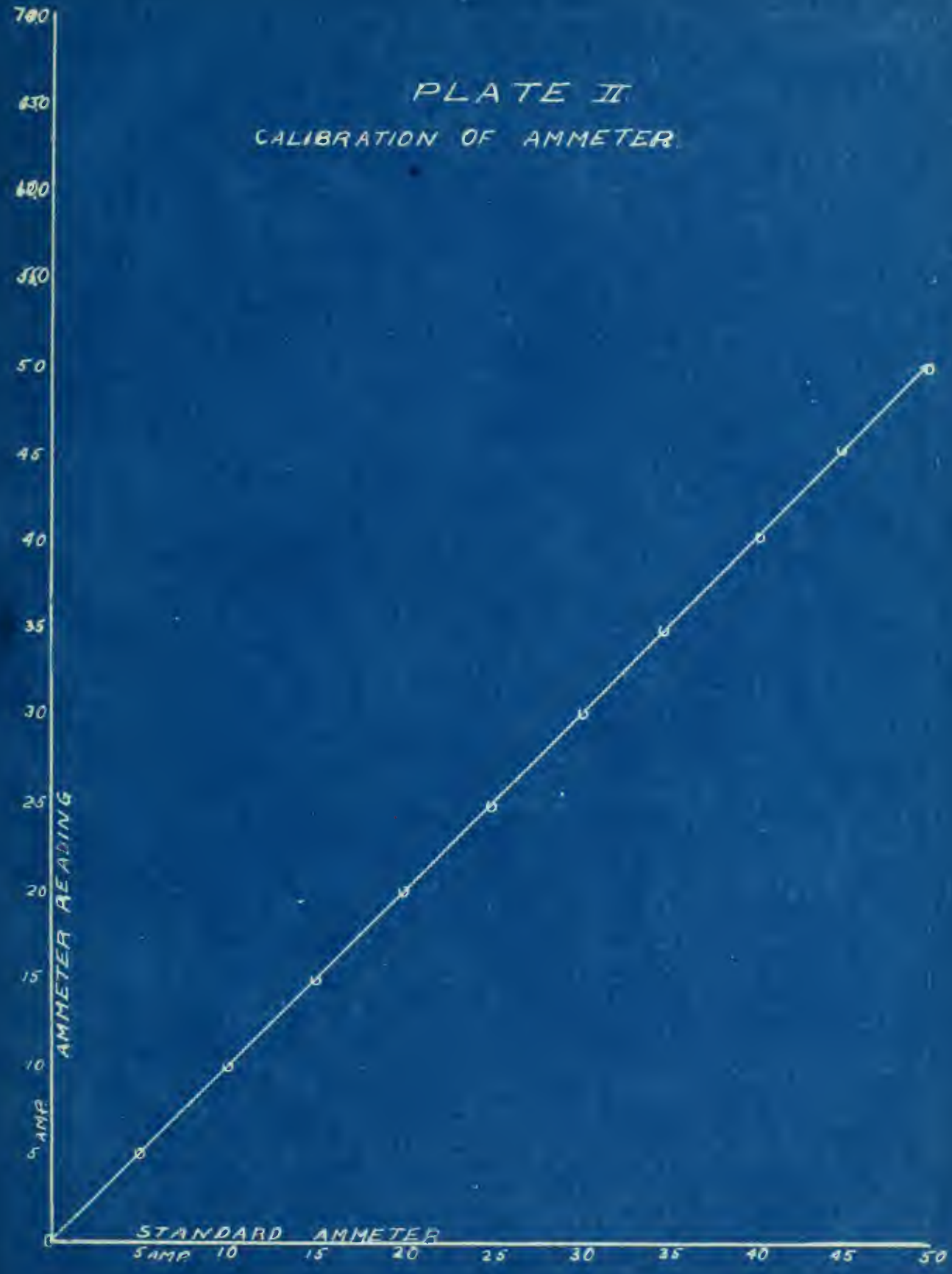
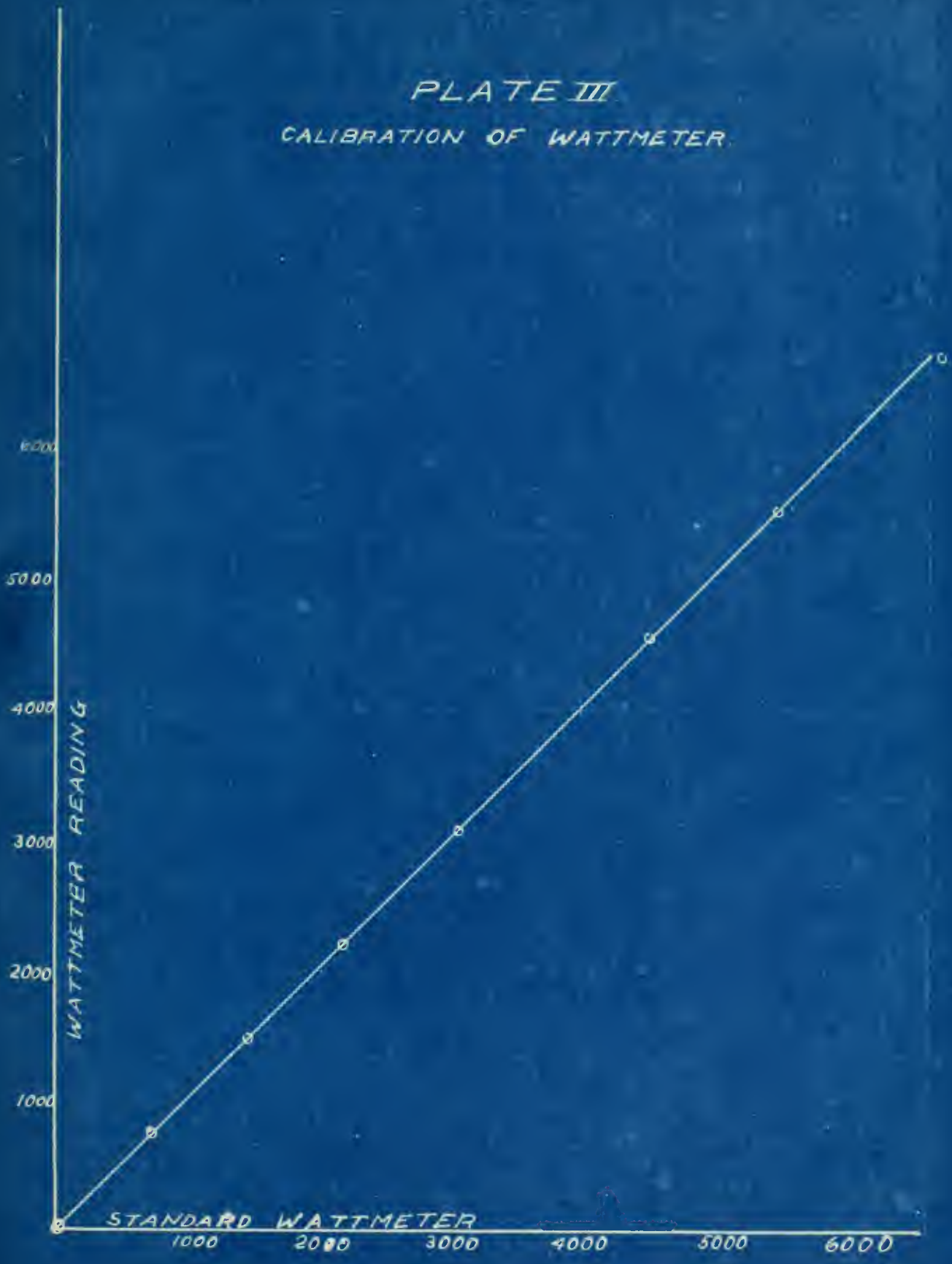


PLATE III

CALIBRATION OF WATTMETER



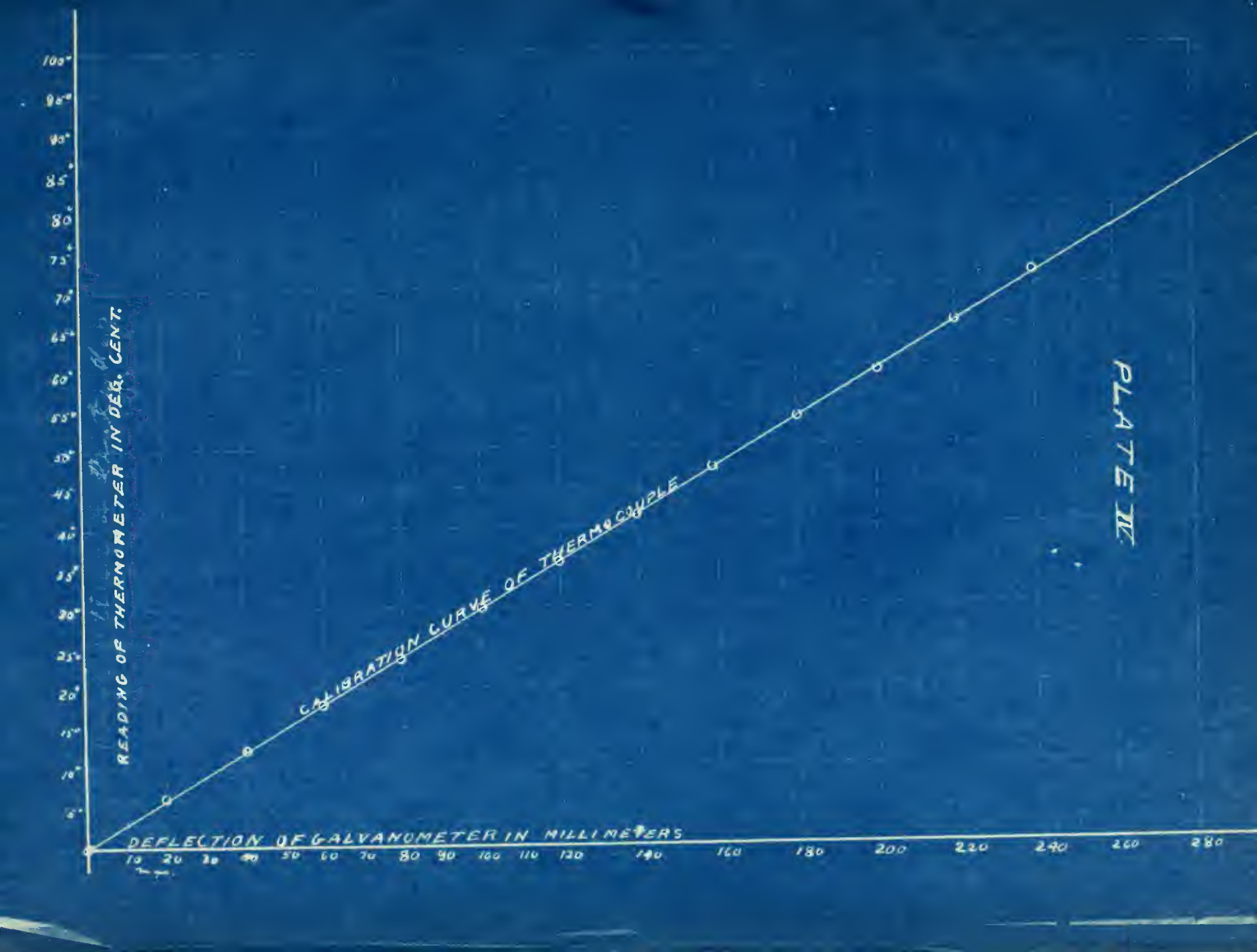


PLATE II
CALIBRATION CURVE OF THERMOCOUPLE
READING OF THERMOMETER IN DEG. CENT.
DEFLECTION OF GALVANOMETER IN MILLIMETERS
10 20 30 40 50 60 70 80 90 100 110 120 140 160 180 200 220 240 260 280

PLATE V.

EFFICIENCY CURVES FOR
MECHANICAL RECTIFER
WITH
APPROXIMATE SINE WAVE GENERATOR

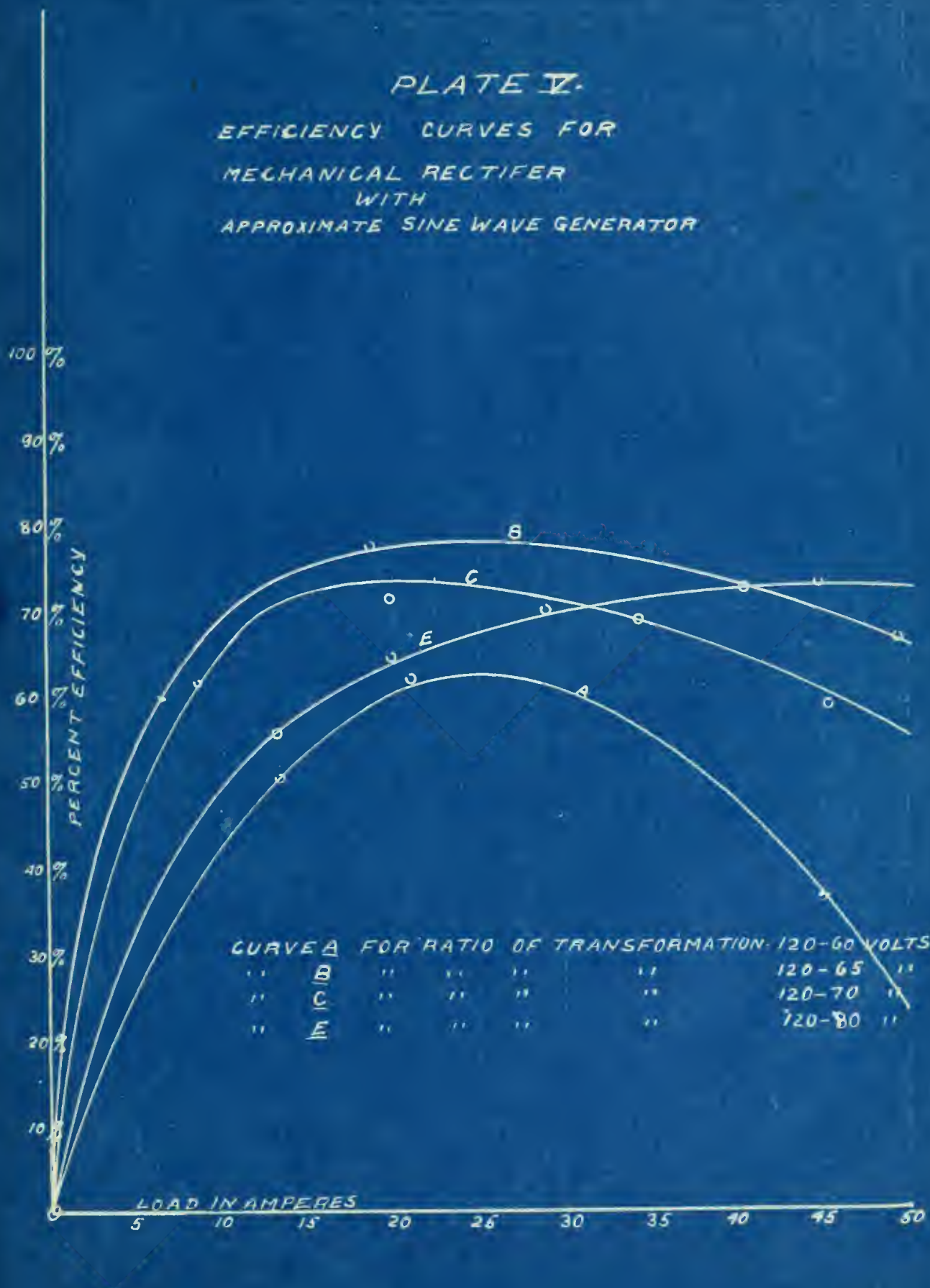


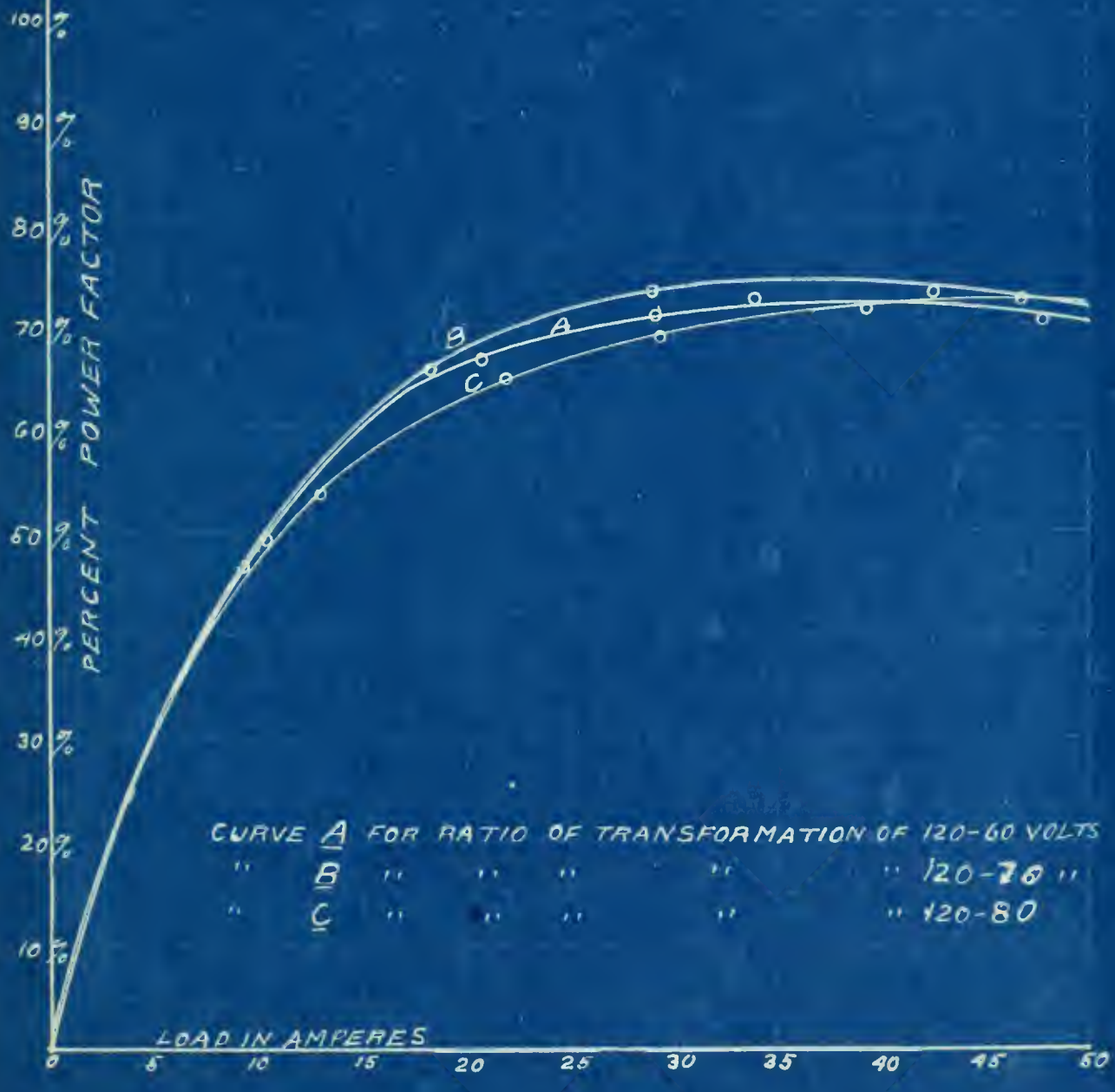
PLATE VI.

POWER FACTOR CURVES FOR

MECHANICAL RECTIFIER

WITH

APPROXIMATE SINE WAVE GENERATOR



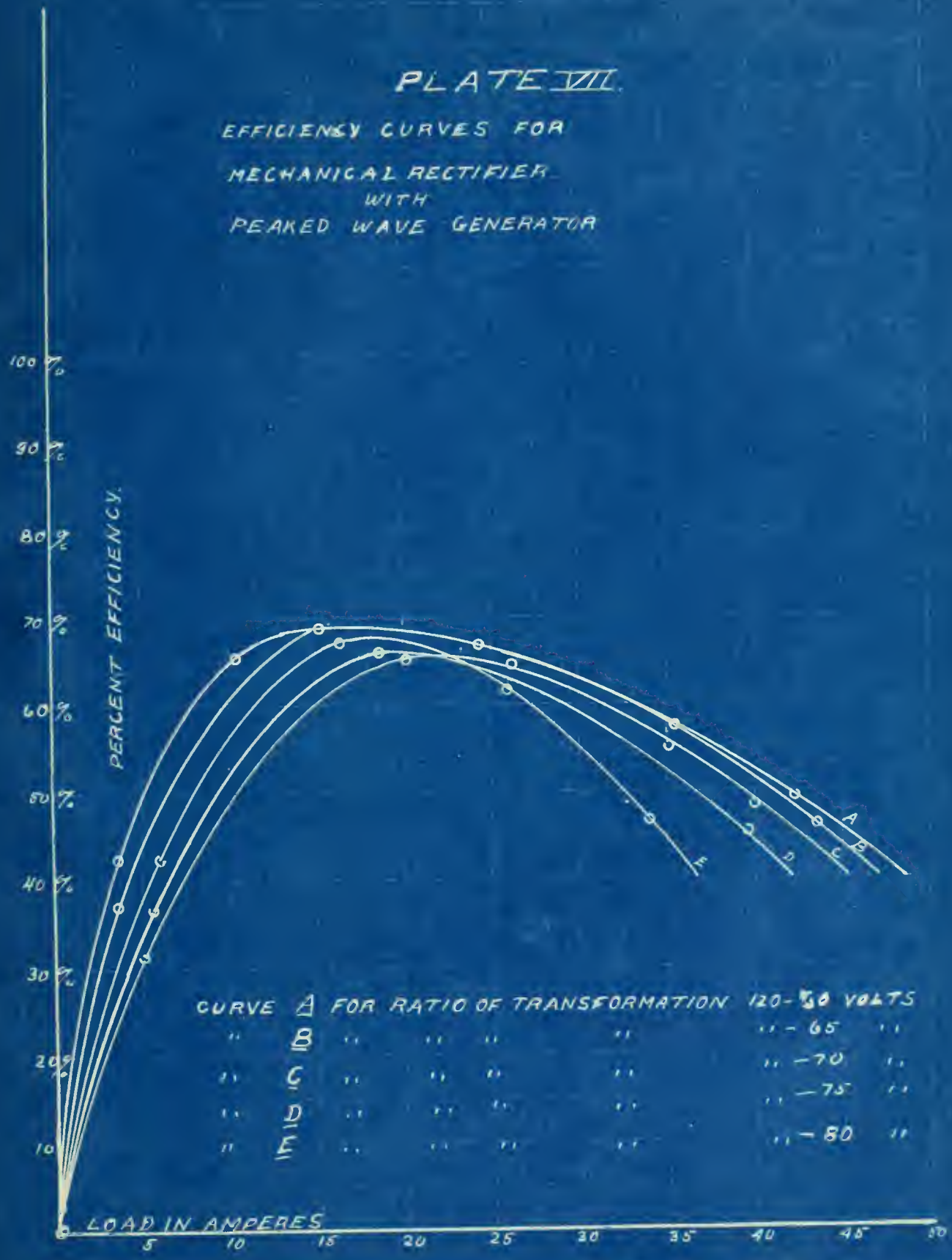
CURVE A FOR RATIO OF TRANSFORMATION OF 120-60 VOLTS

" B " " " " " " 120-70 "

" C " " " " " " 120-80

PLATE VII.

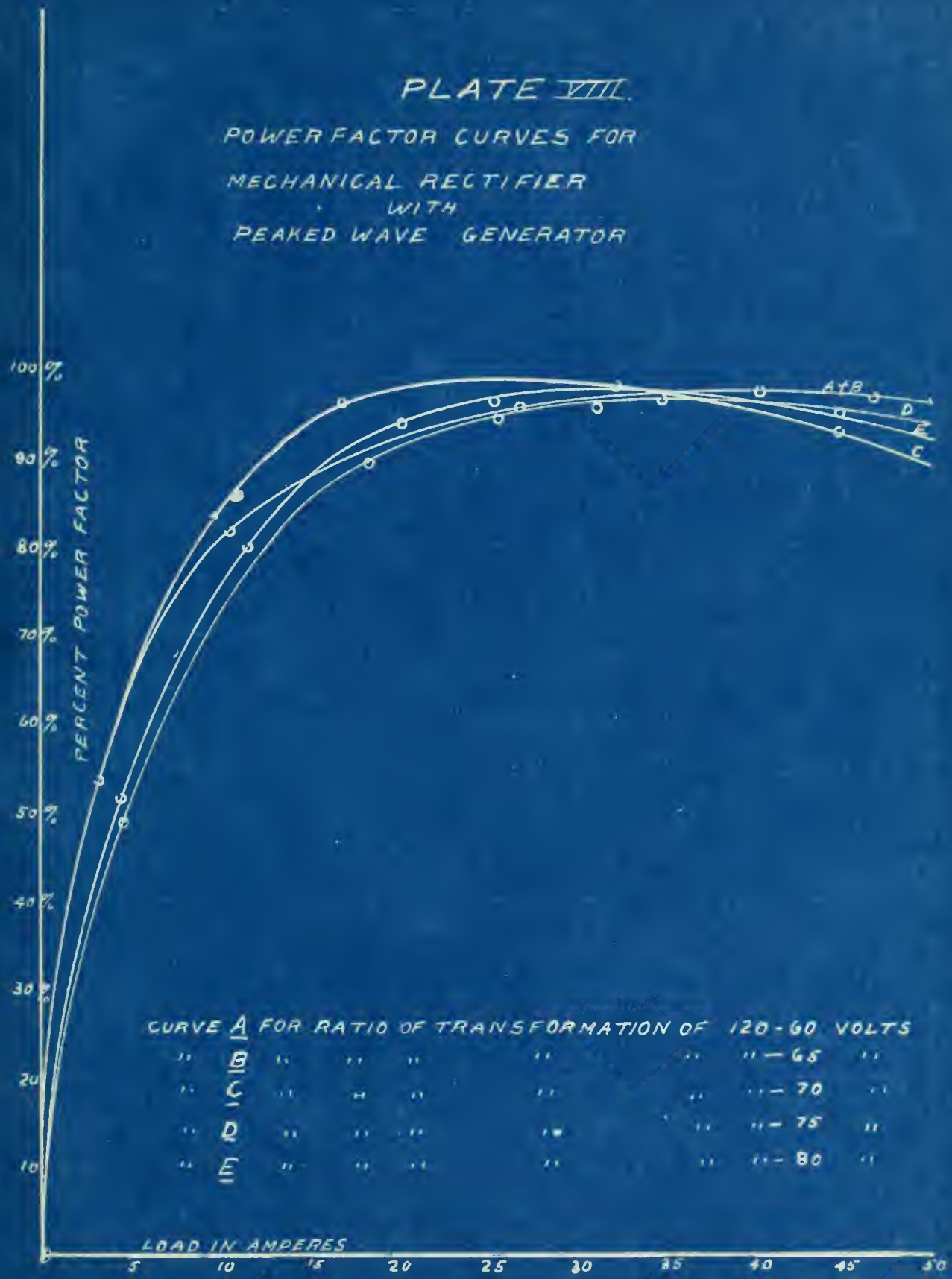
EFFICIENCY CURVES FOR
MECHANICAL RECTIFIER
WITH
PEAKED WAVE GENERATOR



CURVE A FOR RATIO OF TRANSFORMATION 120-60 VOLTS
" B " " " " " " -65 "
" C " " " " " " -70 "
" D " " " " " " -75 "
" E " " " " " " -80 "

PLATE VIII.

POWER FACTOR CURVES FOR MECHANICAL RECTIFIER WITH PEAKED WAVE GENERATOR



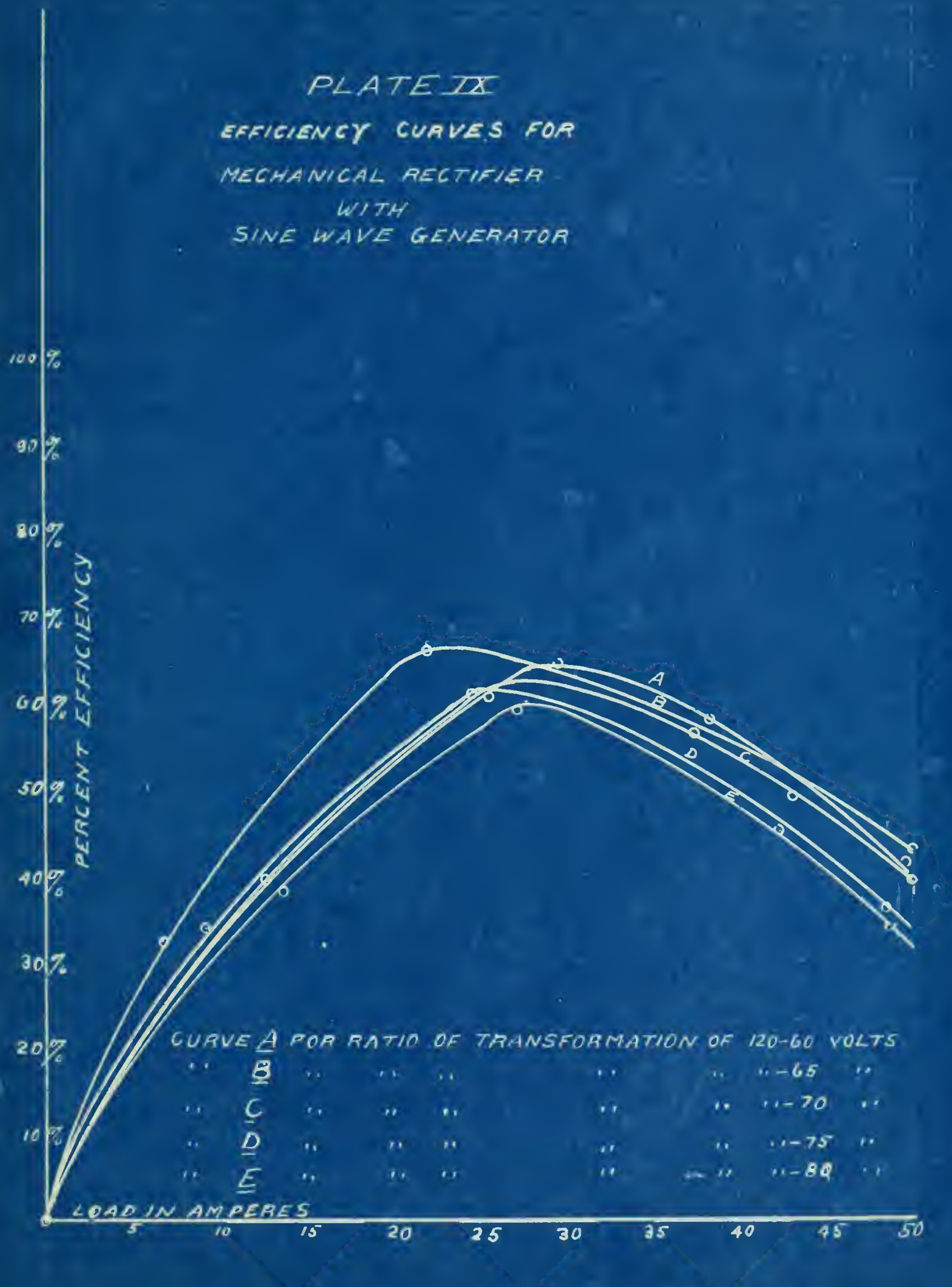
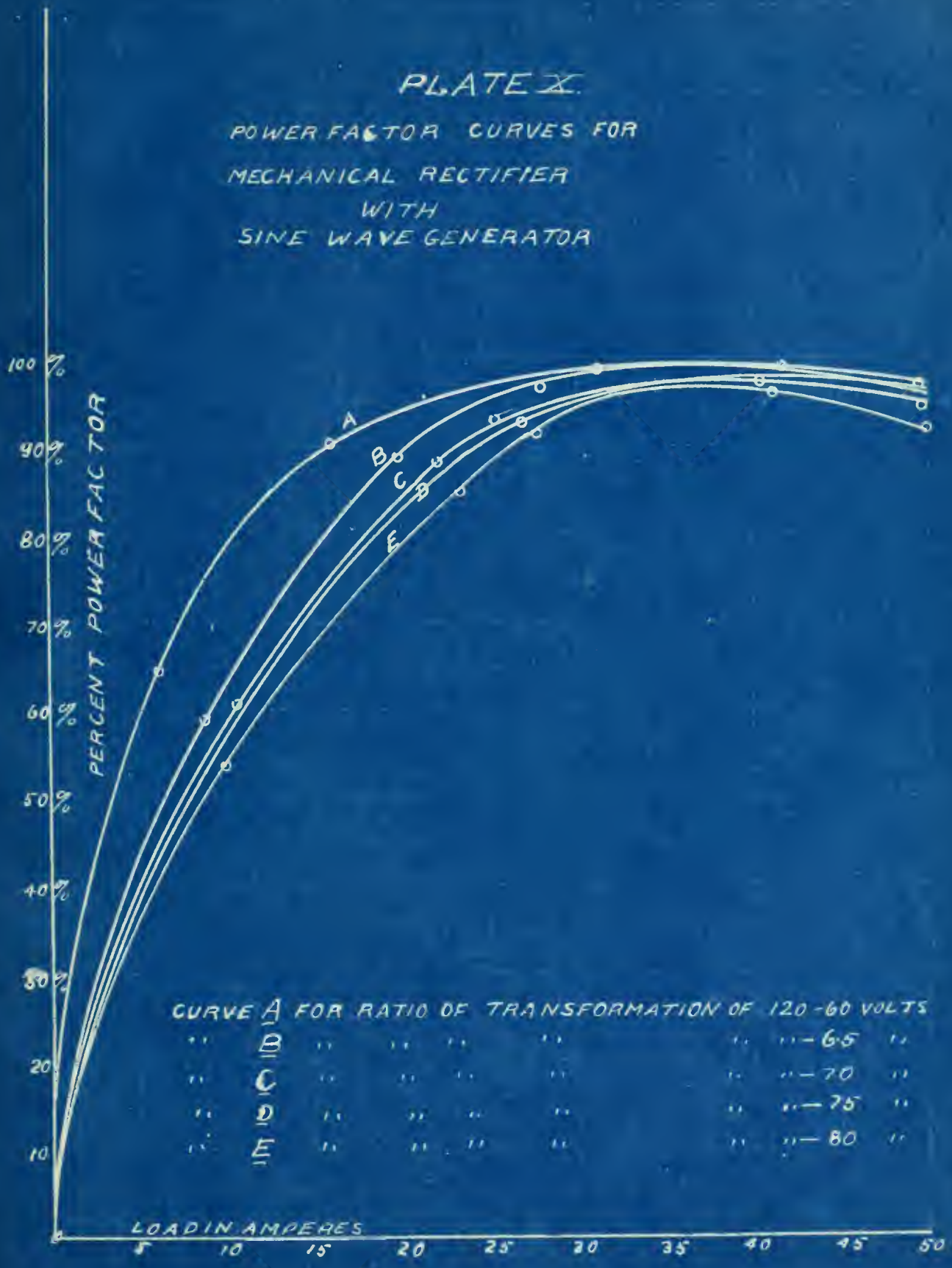


PLATE IX
EFFICIENCY CURVES FOR
MECHANICAL RECTIFIER
WITH
SINE WAVE GENERATOR
PERCENT EFFICIENCY
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
A
B
C
D
E
CURVE A FOR RATIO OF TRANSFORMATION OF 120-60 VOLTS
" B " " " " " "-65 "
" C " " " " " "-70 "
" D " " " " " "-75 "
" E " " " " " "-80 "
LOAD IN AMPERES
5
10
15
20
25
30
35
40
45
50

PLATE X.

POWER FACTOR CURVES FOR
MECHANICAL RECTIFIER
WITH
SINE WAVE GENERATOR



CURVE A FOR RATIO OF TRANSFORMATION OF 120-60 VOLTS
" B " " " " " " " " " —65 "
" C " " " " " " " " " —70 "
" D " " " " " " " " " —75 "
" E " " " " " " " " " —80 "

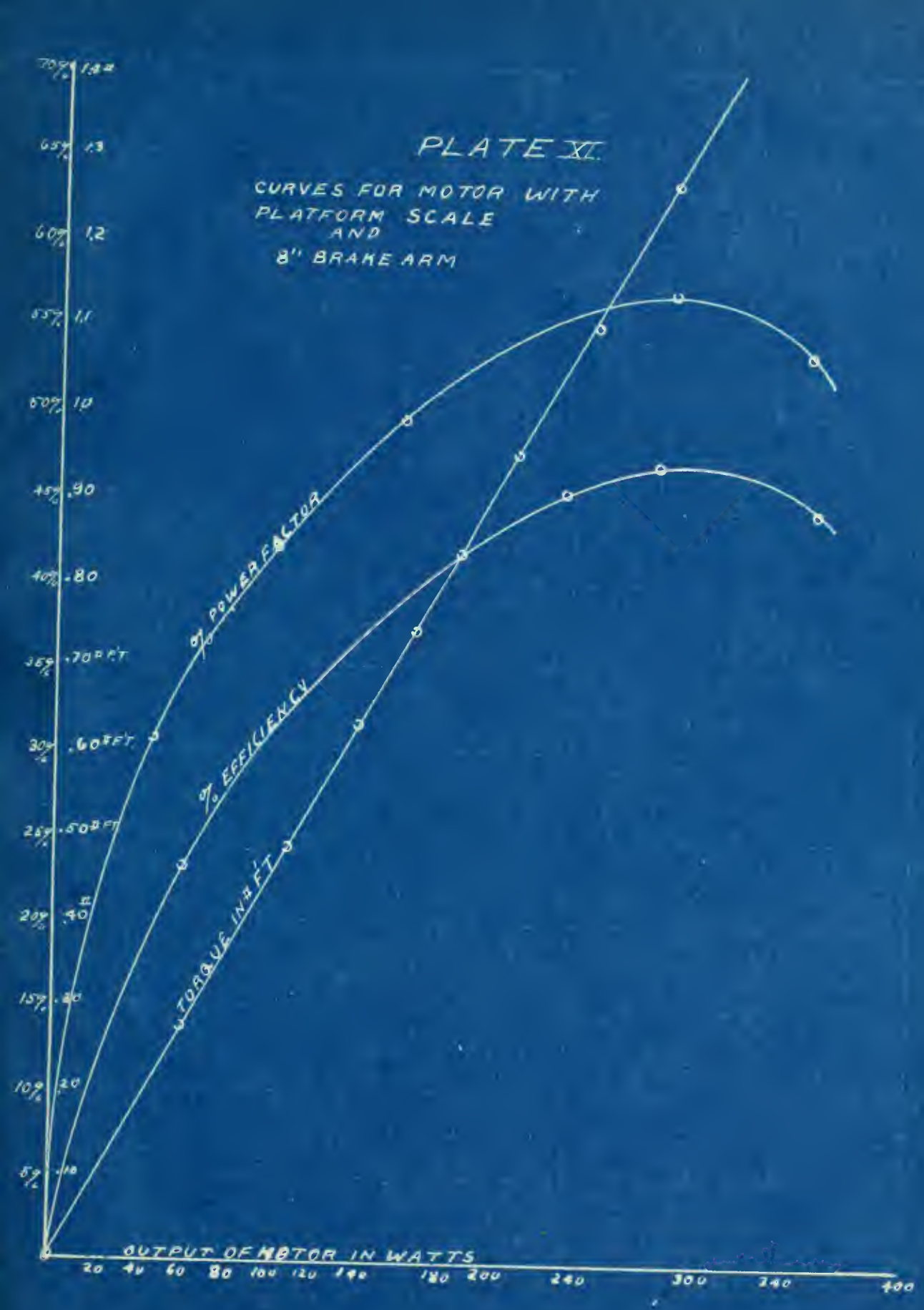


PLATE XI.
CURVES FOR MOTOR WITH PLATFORM SCALE AND 8" BRAKE ARM
% POWER FACTOR
% EFFICIENCY
TORQUE IN # FT
OUTPUT OF MOTOR IN WATTS
20 40 60 80 100 120 140 180 200 240 300 340 400
70% 1.4#
65% 1.3
60% 1.2
55% 1.1
50% 1.0
45% .90
40% .80
35% .70# FT
30% .60# FT
25% .50# FT
20% .40
15% .30
10% .20
5% .10

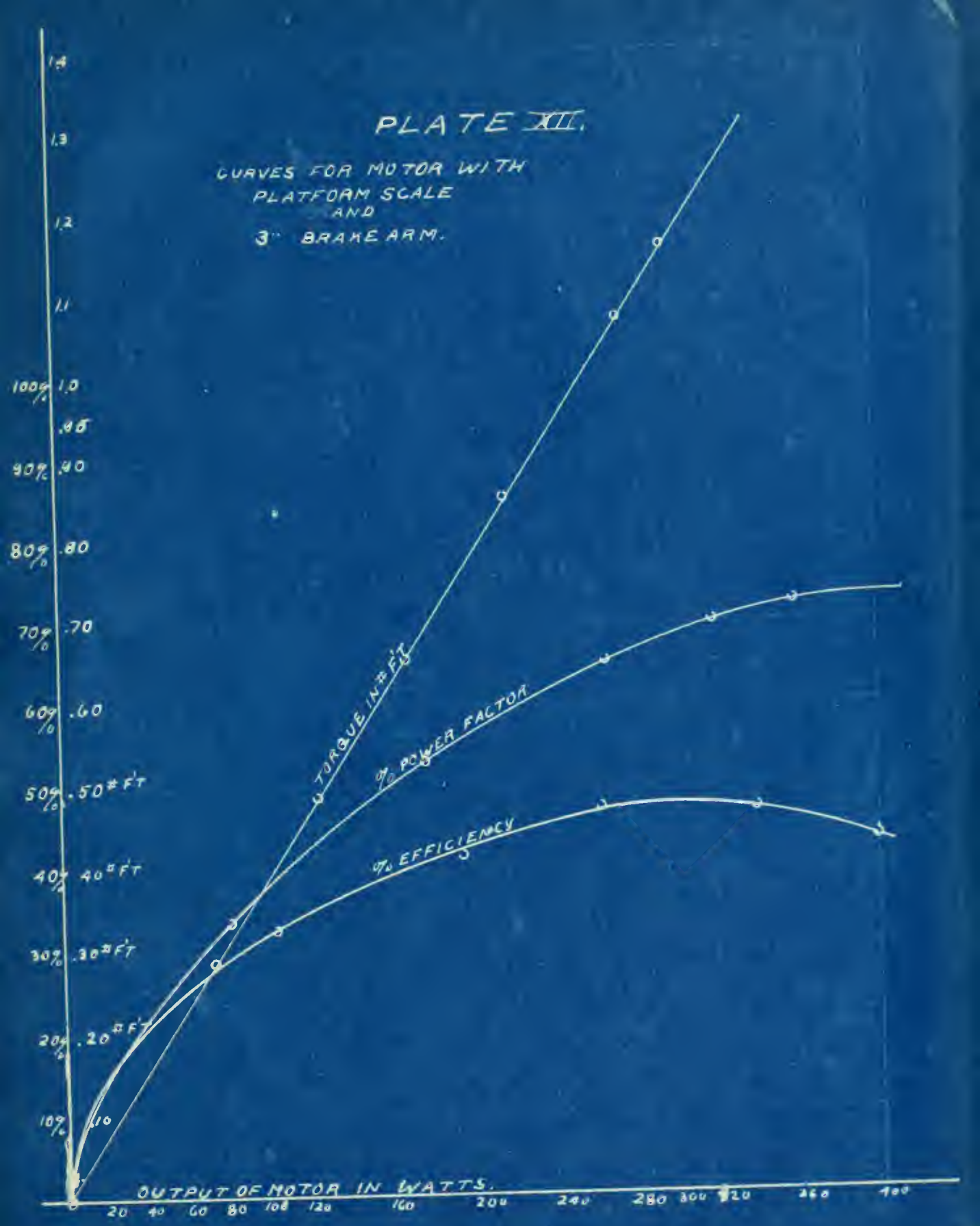


PLATE XII.
CURVES FOR MOTOR WITH PLATFORM SCALE AND 3" BRAKE ARM.
1.4
1.3
1.2
1.1
100% 1.0
.90
90% .90
80% .80
70% .70
60% .60
50% .50 # FT
40% 40 # FT
30% .30 # FT
20% .20 # FT
10% .10
TORQUE IN # FT
% POWER FACTOR
% EFFICIENCY
OUTPUT OF MOTOR IN WATTS.
0 20 40 60 80 100 120 160 200 240 280 300 320 360 400

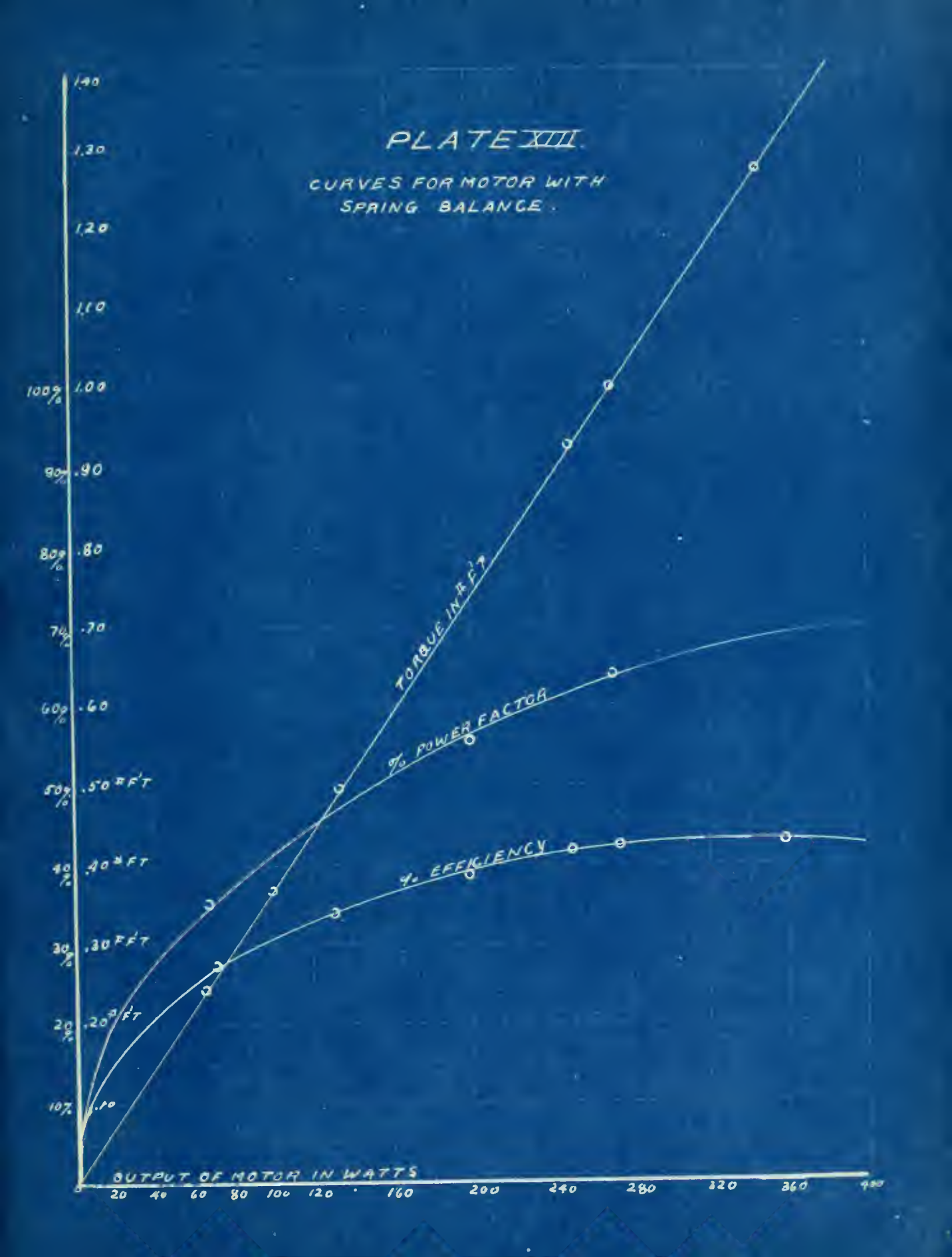
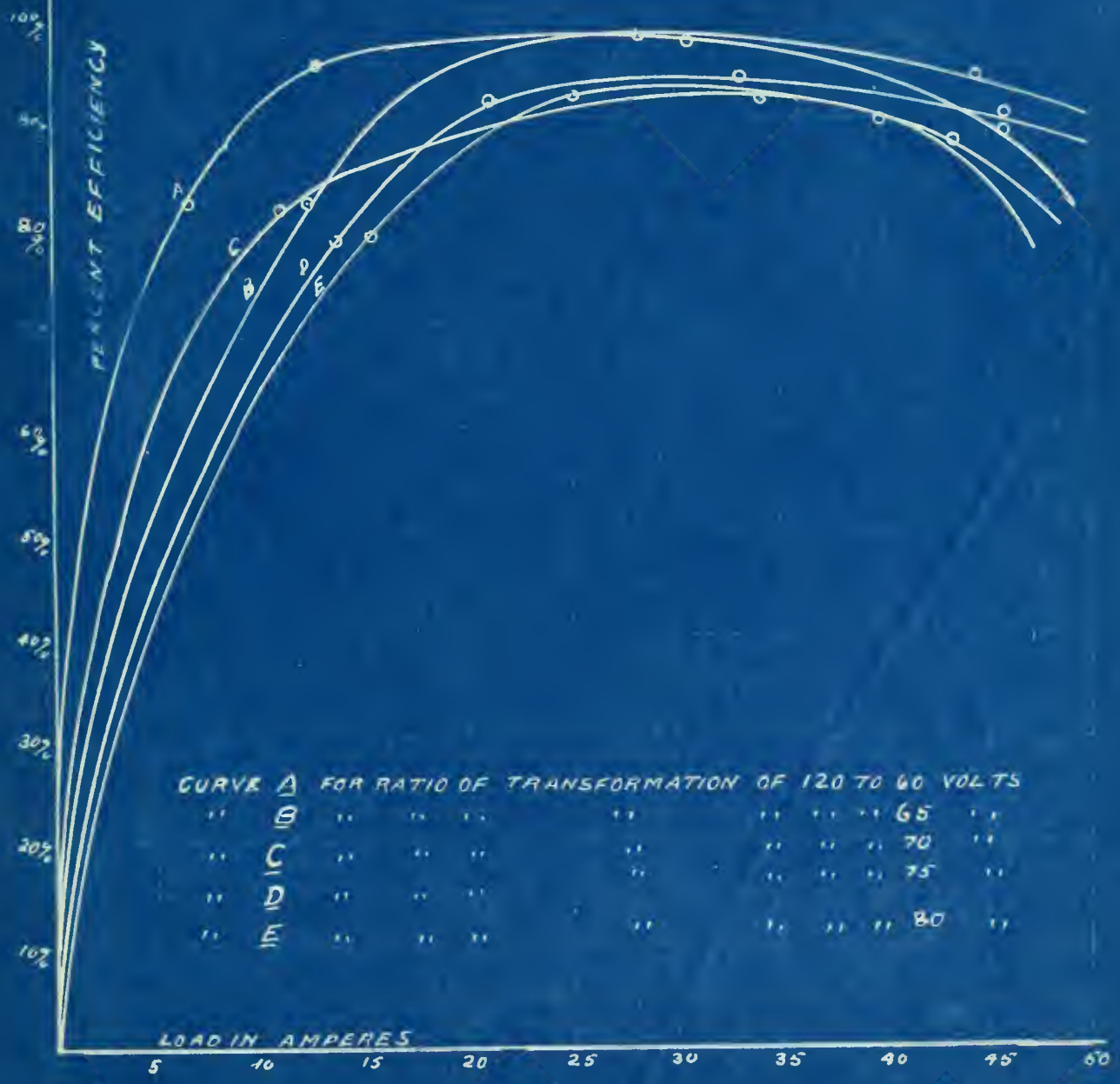


PLATE XIII.
CURVES FOR MOTOR WITH SPRING BALANCE.
1.40
1.30
1.20
1.10
100% 1.00
90% .90
80% .80
70% .70
60% .60
50% .50 FT
40% .40 FT
30% .30 FT
20% .20 FT
10% .10
TORQUE IN FT
% POWER FACTOR
% EFFICIENCY
OUTPUT OF MOTOR IN WATTS
20 40 60 80 100 120 160 200 240 280 320 360 400

PLATE XIV.

EFFICIENCY CURVES FOR TRANSFORMER

BY DIRECT METHOD.



CURVE A FOR RATIO OF TRANSFORMATION OF 120 TO 60 VOLTS

" B " " " " " " " " " 65 "

" C " " " " " " " " " 70 "

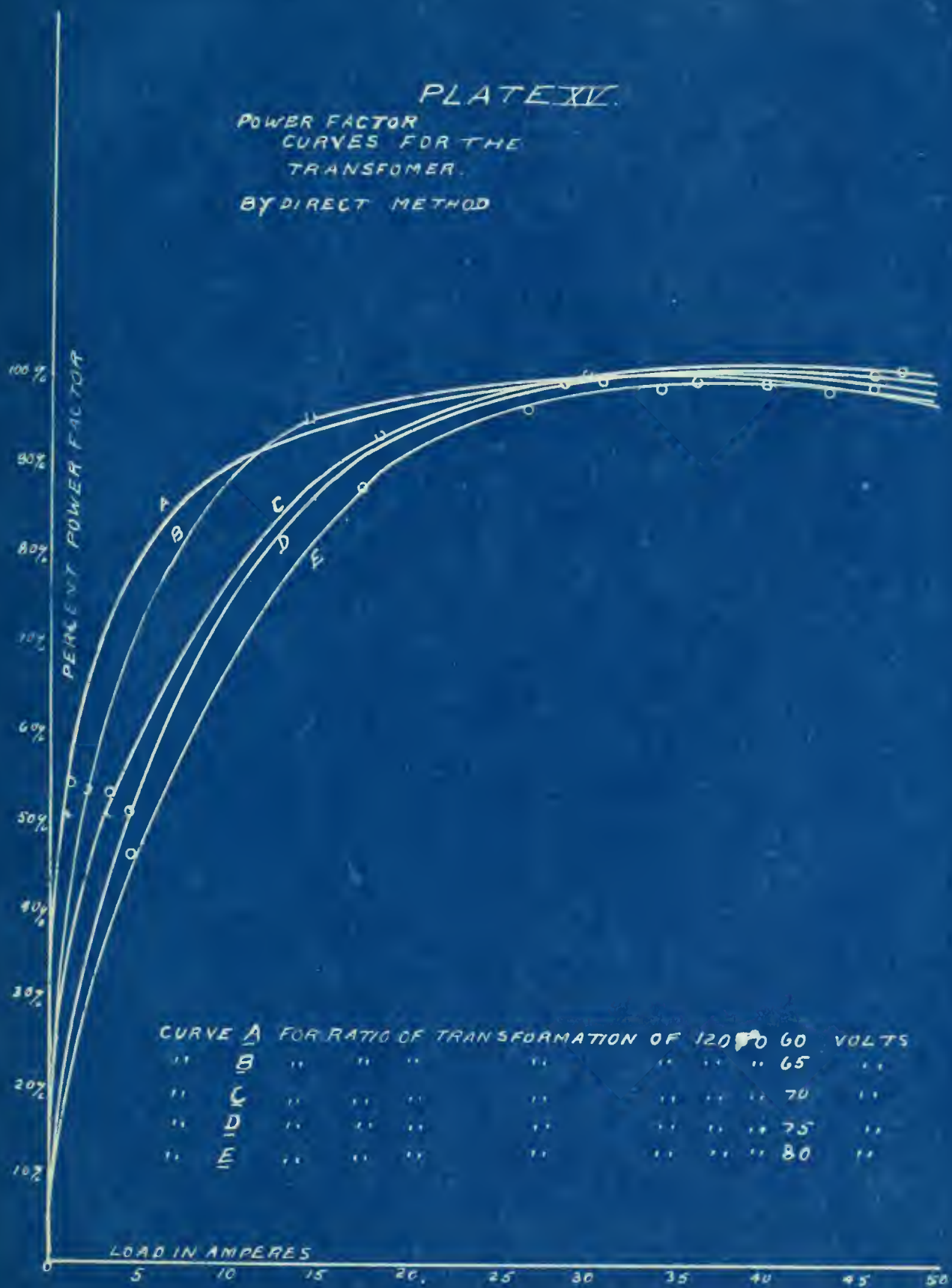
" D " " " " " " " " " 75 "

" E " " " " " " " " " 80 "

PLATE XI.

POWER FACTOR CURVES FOR THE TRANSFOMER.

BY DIRECT METHOD



CURVE A FOR RATIO OF TRANSFORMATION OF 120 TO 60 VOLTS

" B " " " " " " " 65 "

" C " " " " " " " 70 "

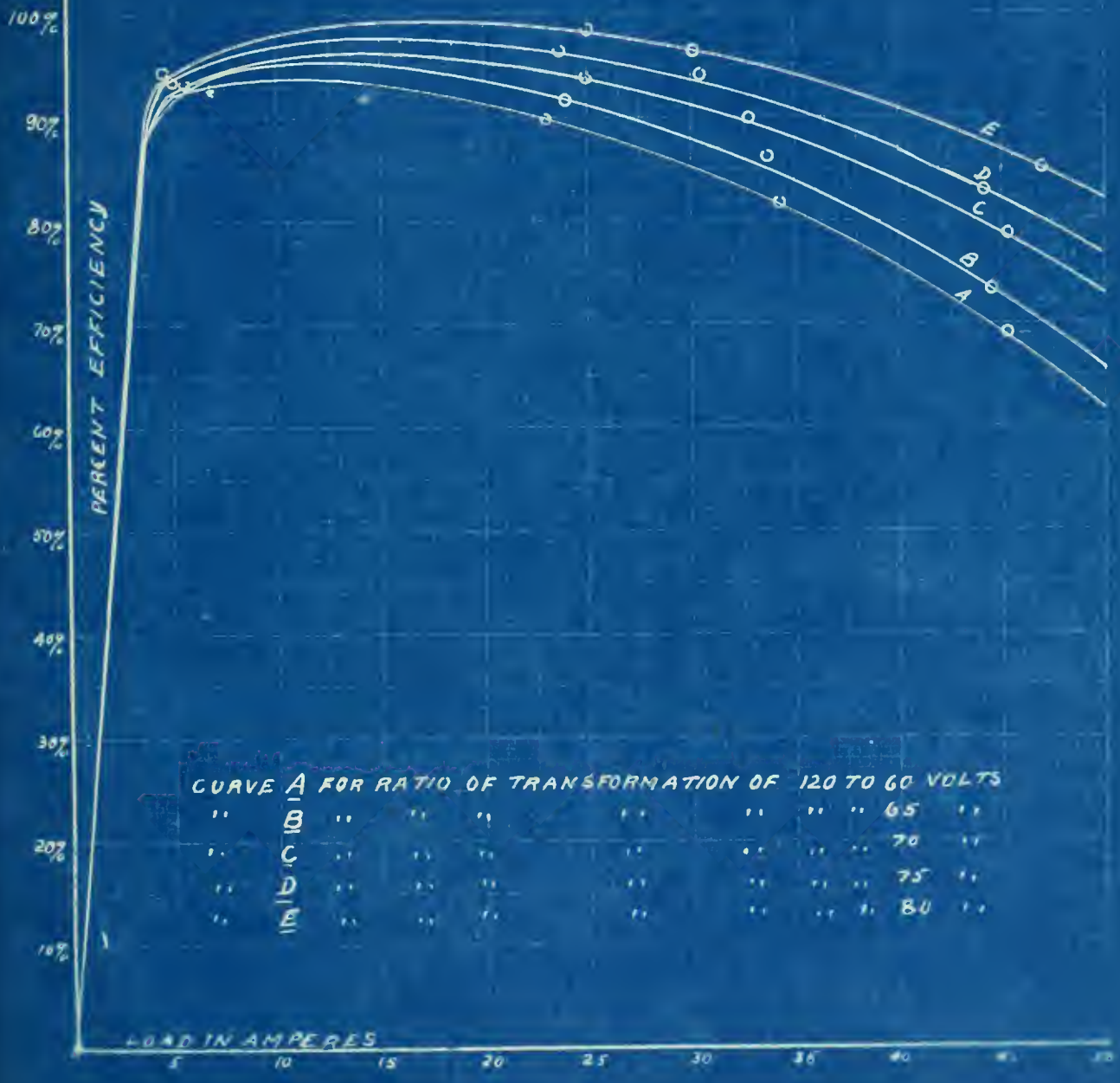
" D " " " " " " " 75 "

" E " " " " " " " 80 "

PLATE XVI.

EFFICIENCY CURVES FOR THE TRANSFORMER

BY METHOD OF LOSSES.



CURVE A FOR RATIO OF TRANSFORMATION OF 120 TO 60 VOLTS
" B " " " " " " " " 65 "
" C " " " " " " " " 70 "
" D " " " " " " " " 75 "
" E " " " " " " " " 80 "

PLATE XVII.

CURVE SHOWING LOSS OF WATTS (I^2R)
IN RESISTANCE WIRE
FOR DIFFERENT CURRENTS

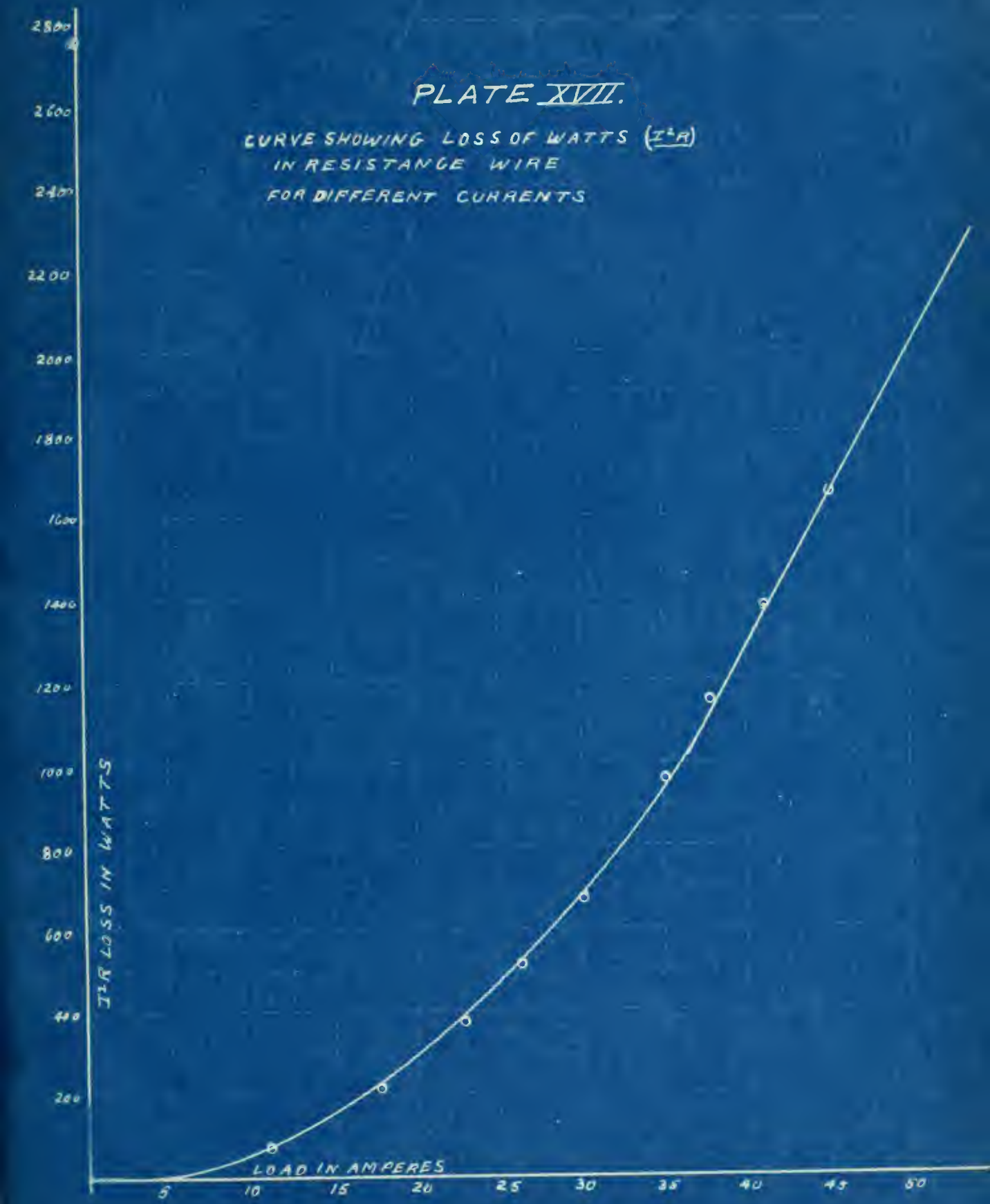
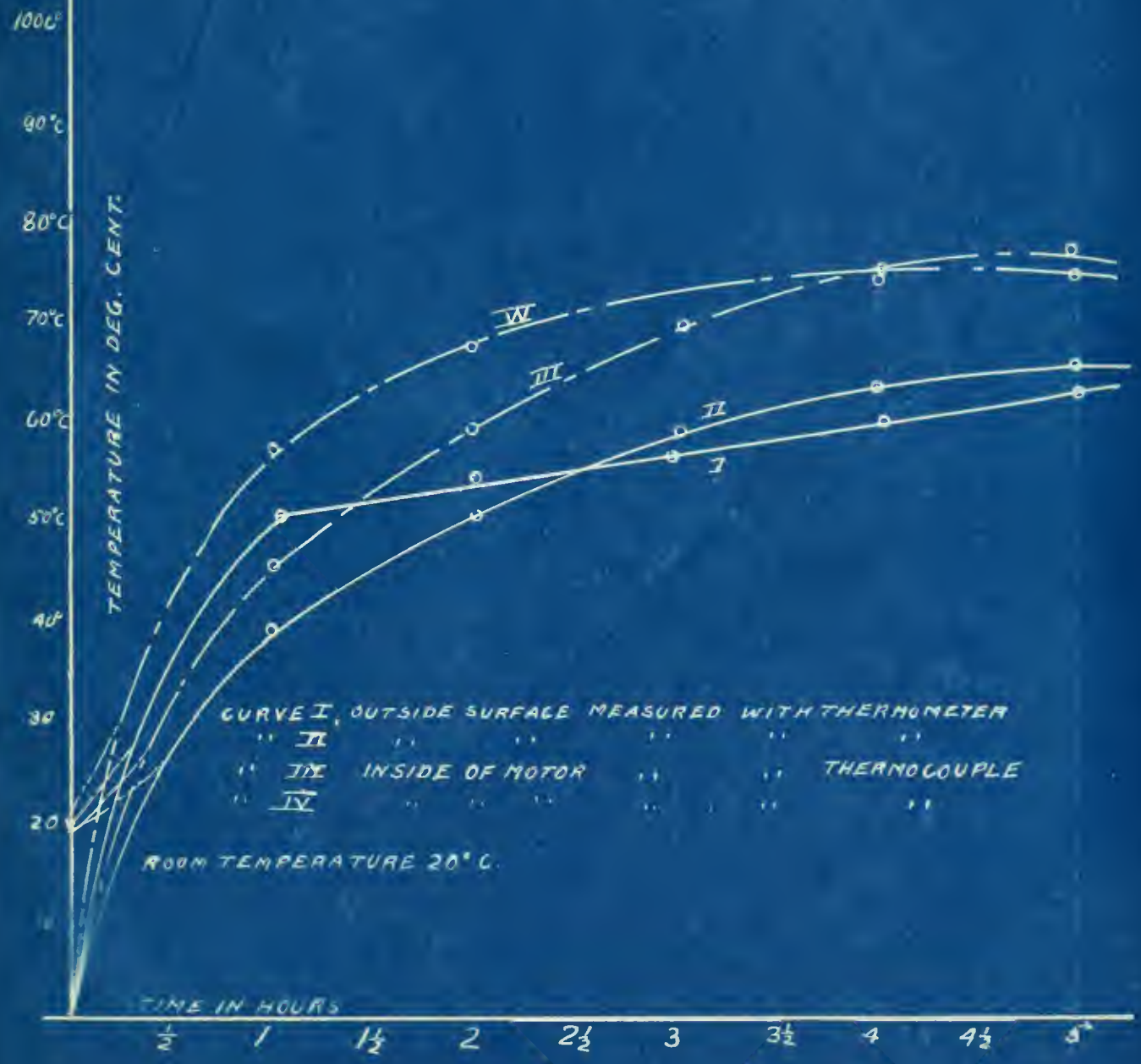


PLATE XVIII

CURVES FOR RISE OF TEMPERATURE OF MOTOR TAKEN AT DIFFERENT DAYS